CUG - H05417-67-a146114

GLIMPSING THROUGH ONE HUNDRED YEARS OF APPLIED MATHEMATICS DEPARTMENT UNIVERSITY OF CALCUTTA

Sir Asutosh Mookerjee

Satyendrananth Bose

Meghnad Saha

Nikhilranjan Sen

DEPARTMENT OF APPLIED MATHEMATICS

UNIVERSITY OF CALCUTTA

2014

GLIMPSING THROUGH ONE HUNDRED YEARS OF APPLIED MATHEMATICS DEPARTMENT UNIVERSITY OF CALCUTTA

67

CALCUTTA UNIVERSITY
CENTRAL LIBRARY

DEPARTMENT OF APPLIED MATHEMATICS
UNIVERSITY OF CALCUTTA
2014

© University of Calcutta

Published in India by the Registrar, University of Calcutta
87/1 College Street, Senate House, Kolkata 700 073
and Printed by Pradip Kumar Ghosh, Superintendent,
C.U. Press, 48, Hazra Road, Kolkata 700 019.

Price : 50.00

Reg. No. 2733B

G-146114

CONTENTS

		Pages
Preface		V
Prologue	*Dilip Kumar Sinha*	1
Genesis of The Department of Applied (Mixed) Mathematics, University College of Science : Historical Perspectives and Vision	*Dilip Kumar Sinha*	4
On The Roadmaps for Development Pursuits in Applied Mathematics	*Rabindranath Sen*	6
A Glimpse into The Past: The Pre-independence Era of Applied Mathematics in Calcutta University	*Bijan Kumar Bagchi*	10
Recapturing Confluences of Indian and Western Influences as A Means for Unfolding Some Dimensions of Applied Mathematics	*Dilip Kumar Sinha*	16
Centre of Advanced Study and DSA Special Assistancse Programme	*Arabinda Roy & Susmita Sarkar*	21
Hydrodynamic Laboratory—Applied Mathematics Department, Calcutta University	*Pradip Bhattacharyya & Ambarish Ghosh*	25
S.N. Bose Institute	*Uma Basu*	38
MA/MSc. Syllabus In Applied Mathematics—Post Independence Period : Some Evolutionary Features	*Arabinda Roy*	39
Activities of The Department : A Contemporary Phase	*Susmita Sarkar*	43
Epilogue	*Dilip Kumar Sinha*	47
Afterword		50
Appendix-I		51
Appendix-II		53
Appendix-III		55
Appendix-IV		57
Appendix-V		58
Appendix-VI		59

PREFACE

The year 2014 is the 150th birth anniversary year of Sir Asutosh Mookerjee who designed Calcutta University as a premier seat of education and research. Under the initiative of Sir Asutosh Mookerjee, in 1914, the University of Calcutta achieved a new dimension by opening different post graduate departments for carrying on advanced level teaching and research. The University College of Science was established in 1914 from the generous funding of Sir Taraknath Palit and Sir Rashbehary Ghose. The post graduate departments in applied sciences including Applied Mathematics were started there in 1914. At that point of time this Applied Mathematics Department was named Mixed Mathematics Department.

Professor Satyendranath Bose, Professor Meghnad Saha and Professor Nikhil Ranjan Sen were students of this Department in the session 1913-15. The great visionary Sir Asutosh Mookerjee identified these budding scientists and appointed them as teachers immediately after their passing out. Apart from these three legendary scientists, last hundred years of this department were also enriched by many other Applied Mathematicians like Prof. Ganesh Prasad (first Rashbehary Ghose Professor of Calcutta University), Prof. B.B. Dutta, Prof.S.K. Banerjee, Prof. N.N. Sen, Prof. S. Ghosh, Prof. B.S. Ray, Prof. S.K. Chakraborty and others for their illustrious contributions in different branches of Applied Mathematics.

The Department of Applied Mathematics, University of Calcutta has organized an International Conference in February, 2014 to commemorate these glorious events and has decided to document the history of last hundred years (1914- 2014). For writing this history department has formed a committee comprising of Prof. S. Sarkar (Head of the Department), Prof D.K. Sinha (Chairman), Prof. A. Gupta, Prof. K.P. Das, Prof. S.C. Bose, Prof. A. Roy, Prof. R.N. Sen, Prof. S.S. De, Prof. C.G. Chakraborty, Prof. P.K. Chaudhuri, Prof. U. Basu, Prof. B. Bagchi, Prof. S. Sen and Dr. P.K. Bhattatcharya (Invitee).

This publication would not have been a reality, hadn't our department received the unstinted support of our respected Vice-Chancellor Prof. Suranjan Das.

We are thankful to all of them who have helped us to get the sources of information which was not at all an easy task. Thanks to Sri Pradip Kumar Ghosh, Superintendent, Calcutta University Press and his colleagues, as well.

Susmita Sarkar
Professor & Head
Department of Applied Mathematics
University of Calcutta

PROLOGUE

Dilip Kumar Sinha
Formerly, Sir Rash Behary Ghose Professor of Applied Mathematics, University of Calcutta
e.mail : dilipkumarsinha@rediffmail.com

Any account on the origin and development of Applied Mathematics/Mixed Mathematics Department in the realms of Calcutta University has to consider necessarily milieus on mathematical pursuits, prior to the initial days as a formal Department of the University. True, that Presidency College, Calcutta along with its earlier garb, Hindoo College, witnessed the study of mathematics without being insensitive towards allowing pupils for working on applications on mathematics, in wider contexts. Indeed, hadn't there been the mathematics Professor Tytler, there would not have been the unfolding of the prodigy Radhanath Sikdar being recommended by him for appointment as a 'Computor' in the erstwhile Trigonometrical Survey of India. One should refer to a handful of institutional/organizational pockets that catered to mathematical instruction. Historically speaking, Presidency College, Calcutta had an edge over others, in offering mathematical teaching and learning and that needs to be reckoned with for mathematical studies with 'applied' nuances. Indian Association for the Cultivation of Science established in the seventies of nineteenth century, turned out to be a forum where exercises on mathematical sciences through lectures, along with relevant upshots, started off making a dent, as well.

That Calcutta University, chiefly an examining body, ought to be mapped on to as an academic establishment could become discernible in the early part of the last century, under the leadership of Sir Asutosh Mookerjee. It could be sagaciously felt that a systemic transformation of the University of Calcutta could be ushered in only when ongoing activities could be consolidated and all the more genuinely so, in building the bedrock, rather the subsystems, of the envisaged University of Calcutta. So, in a way, one has to delve in perspectives shaping the kinematics of the growth paths of the University of Calcutta and its departments, in particular, the Applied (Mixed) Mathematics, to the benefit of both. The University Calendars, for apposite periods, should well testify to the thought-process about the Department of Applied Mathematics. Among the convocation addresses by the Vice-Chancellors of the University of Calcutta, those of Sir Asutosh Mookerjee referred immaculately to the areas relating to teaching and research in the field of mathematics, whether they be pure or applied. Any historical document on the department of applied mathematics cannot but draw upon valuable and pertinent excerpts of such addresses. Did the usage of the word 'applied' with 'mixed' in a parentheses, pose a dilemma or a discourse at a certain point of time in the chronology of the Department ? That needs to be dwelt upon, mainly to bring to focus, the impact of western thought styles and approach, too. That the founding of the Calcutta Mathematical Society, under the stewardship of Sir Asutosh Mookerjee must have buttressed the research- dimension of mathematical endeavours has to be taken into account. That budding figures never abjured aspirations to be leading personalities in mathematics need to be recounted. As it often happens even today, exposures to new and challenging areas, such as aspects of celestial mechanics, used to be part of activities on applied mathematics. As a matter of fact, Mechanics and Astronomy with their connotations and dimensions in those days, occupied layers of the investigation and instruction in the first and second decades since the birth of the department. Don't these resonate with what Henri Poincare and Leonhard Euler thought and took on, few centuries earlier?

A definitive historical tenet ought to lie in the identification of phases of the department allowing such exposures to find a definite site in its instructional framework(s) for few decades. Cantabridegeans and wranglers must have wielded influences in developing courses and rich contours of research in the department. A simple hindsight ought to find the European influences creeping gradually into the Department. Isn't it a landmark of the department when the trio—Prasanta Chandra Mahalanabis, Meghnad Saha and Satyendra Nath Bose, translated the Einstein's classic work on General Theory of Relativity ? That did happen, even if, the faculty were immersed in teaching classical areas of Elasticity, Fluid Dynamics, Geodesics and Geophysics and so, the outreach capability of applied mathematicians could ensue in the second decade since its inception.

A few pertinent points need to be kept in view. It is definitely because of the efforts of Sir Asutosh Mookerjee, there could be two Sir Rash Behary Ghose (Chair) endowment Professorships and that one happened to be in Applied Mathematics. Historically speaking, the Department of Pure Mathematics, had taken off much earlier in the precincts of the University. Asutosh Mookerjee saw to it that because of the munificence of Lord Hardinge, the Hardinge Professor of Higher Mathematics, could be created. Presumably, there did not exist any nemesis in mathematical realms so as to have the label, either pure or applied. It is equally true that the usages mixed/applied, continued for, not on scores of indecisions but because, the new outfit in the University was gradually seeking the identity, uniquely on its own. This is all the more evidenced by the University Calendars. Since the early thirties, it looks that the usage of the word 'applied' could come to a stay.

The image of the department in the public domain, or at least in the domain of takers of studies in the discipline, could become glaringly conspicuous, as evidenced by the simple numerical figures opting for pure and applied mathematics in annals of the University of Calcutta. Gleaning through the research papers of some teachers of the department does reflect inclinations in classical directions. But leaderships that mattered most were for providing global perspectives towards study and research. An appraisal in qualitative terms, has already put the dynamics of the department in excellent shapes. The roping in the faculty of Presidency College continued unabated, at least in the instructional arena. That formed the mainstay of the department acquired in pre-independence days and a bit later, as well. Incontestably, with such a repository of high level attainments, the department could be identified by the University Grants Commission (UGC) as a Centre of Advanced Study in Applied Mathematics under the leadership of Professor Nikhil Ranjan Sen. The first report on Mathematics, under the aegis of UGC, bears well testimony to this. His envisioning of the Department, somehow or the other, did not pay dividends. Needless to go back to pages of history, Sir Asutosh was keen to have the Applied Mathematics department coexisting with other departments of science, pure/applied, in the portals of the University College of Science. Applied research could hardly thus go by default. Hydrodynamical laboratory was a part of Professor Sen's conceptualization in such contexts. That few collaborative ventures mattered most should be valuable segments of the history of the department. Few more exceptional endeavours in thus direction need to be mentioned.

Expectedly, the department must have carved out nonlinear pathways that should have kept on evolving through the compulsions of the times. Yet, it had to suffer because of being treated indiscriminately at high levels. That the alibis were far from being reasonable and impartial could be realized when the same status could be restored to it, almost a decade later. The department can be proud of having offered M.Phil. courses through its academic wing, as the Satyendranath Bose Institute of Physical Sciences, in which interdisciplinary and interactive modes on a wider canopy could become visible to a broader community of takers. A disquietingly sordid tale on such scores, stands as an example of denial of a recognition of endeavours of those who paved the way relentlessly for building up a vital institution in the name of S.N. Bose.

An array of phase portrayals of the department has, of late, become a necessity so that new vistas of development can come up in the view of what applied mathematics stands for and what it ought to be so as to absorb the quintessence of modern developments, without being a purist in any direction whatsoever. Any layout on glimpsing through facets of applied mathematics, as pursued earlier and being envisaged now, can in no way dispense with what ought to figure in, despite some areas there being incomplete and some, yet to begin. A rationale for seeking a foundational critique of the Department of Applied Mathematics is definitely called for.

An account on the products of the department, whether situated in the country or abroad, is a necessity because of what they keep on enriching frontiers of mathematics *per se*; also, for a variety of contributions they may have put in elsewhere. In sum, problem-solving continues to be the abiding *forte* of the department, perhaps much to the dismay of those incapably equipped to take on problems, to say the least, in classroom scenarios.

GENESIS OF THE DEPARTMENT OF APPLIED (MIXED) MATHEMATICS, UNIVERSITY COLLEGE OF SCIENCE : HISTORICAL PERSPECTIVES AND VISION

Dilip Kumar Sinha
Formerly, Sir Rash Behary Ghose Professor of Applied Mathematics, University of Calcutta
e.mail : dilipkumarsinha@rediffmail.com

No part of the world where mathematics has kept on flourishing has ever distinguished between labels of mathematics. The queries on human activity being taken on by mathematics continue to be lively even today. Whither mathematics as arts or science could not be resolved by the examining outfit of Calcutta University. Naturally, as shown in University Calendars, while Pure Mathematics has existed, over the decades, and has a separately entity, Mixed/Applied Mathematics has had its doors respectively open to both Arts and Science. The closeness of Applied/Mixed department to Arts/Science continues to be a timeless question. But in terms of the historical matters, one can always raise a loftier issue in regard to the perennial question on the naming the department.

The species of mathematical practitioners even at the grassroot and subaltern levels, have come to stay, whether they be legislative mandates or not. There exists a fairly general amount of literature even in Indian ambits, a realisation that here is s discipline that differs in terms of conspicuity from others. The appendage of mathematics to humanistic studies, not purely because of its receptively open traits, has not been given up, even during the colonial period. Trade commerce, industries, merchants, navigational work, survey work etc. must have necessitated personal equipment in mathematics. Otherwise, Radhanath Sikder, thoroughly embedded in Derozian flavour, could not have evinced his scaling up Mount Everest. One can well preempt, at that point of time, trigonometry as the language of classical astronomy.

A formal, if not run-of-the-mill, outfit was found to be very much in the offing. Presidency College, under then direct umbrella of the British Raj, could wipe out the earlier vestiges and assumed elitist stances on mathematics *per se*. The overseas mathematics, particularly from England had its sway. Professors Cullis and Booth could transcend colonial misgivings and inspired Asutosh Mookerjee and others. Exposures to what kept on happening abroad, particularly in England in mathematically intellectually citadels found their pathways. Looking back, one cannot say in definitive terms, whether such exercises could be linked to open-hearted feelings. On the contrary, dividends did accrue in developing nearly insatiable thirst for having direct interactive modes abroad. Asutosh Mookerjee hardly relented himself from correspondences with leading personalities and organizations, too. A decade later, Devendra Nath Mullick, could hardly resist himself from going abroad and could have a mode at Cambridge for a much-wished-for Tripos. Mullick's ostracism from the village community at Bagnan (Howrah district in West Bengal) did not prevail upon him later on to be mathematics-drop out.

D.N. Mullick, employed in the Presidency College, became a doyen among the Faculty. It often sounds like a pity, in the hoary days of Presidency College, that the aura around him has not found echoing, as one finds with P.C. Ray and J.C. Bose, who had sojourns there from their study abroad.

Remarkably, brilliant students like Satyendra Nath Bose and Meghnad Saha took to Honours and Masters in Mathematics from Presidency College. D.N. Mullick's *forté*, as recaptured by his pupils, was his teaching of Mechanics and Astronomy. Most of the students, who excelled in research later on, used to be eloquent on Professor Mullick, starting off his lecture every day *ab initio,* and that coping with the problem used to be distinguishably distinctive. So problem solving, as a cardinal tent of mathematics teaching and learning, acquired an innovative site in instructional exercises of Professor Mullick. None of his students seldom missed in every class that he used to be inching towards a state of mathematical grace and finesse.

The University department, applied (mixed) can, in no way, disown its genesis traceable to postgraduate studies in the erstwhile Presidency College. The legacy of applied (mixed) mathematics, doubtless began with Mechanics of Particles and Rigid Dynamics, Statics, Hydrostatics, Hydraulics and Hydrodynamics. These are, in some ways, some sort of moorings in applied (mixed) mathematics. The nexus of times must have played roles so as to have a characterization of applied (mixed) mathematics. The teaching materials in those days were exemplary, particularly the one by Professor Mullick on 'Spherical Astronomy'.

One may say that dilemma continued about contents of applied (mixed) mathematics, primarily because of desired ambits of its possible dimensions. Presumably that required the University College of Science, to have an indelible framework on mathematics with a label that permitted an allowable characterization. In regard to the basic concepts and notions that one may ascribe to applied mathematics, an exhaustive epistemological treatment has stand to reality. The founding of the Department of Mixed (Applied) Mathematics was in quest of developing a characterization relating to a situation of problems, if not *in situ*, drawn from some segments of the applied sciences/technology.

Situating the department in the precincts of he University College of Science, could be appositely envisaged by the founder, namely Sir Asutosh Mookerjee and his cohorts. A genre of applied (mixed) mathematics could afford to be initiated because of the mathematical consortium Asutosh built up through Calcutta Mathematical Society. The Asiatic Society of Bengal provided the forum for the Indian Science Congress Association to hold its first Congress, on the lines of British Association for the Advancement of Science. In passing, on should say that Professor D.N. Mullick happened to be its custodian in the Section of Physics and Mathematics Section. The rationale for the establishment of a separate Mathematics became all the more pronounced in the university system, largely because of inadequacies somewhere without being bereft of visions, as well. Asutosh Mookerjee became a rallying personality for celebrities like Gooroodas Bandopadhyay, Brojendra Nath Seal, Mahendralal Sarkar, A.C. Sengupta, around him. That the organ of the Calcutta Mathematical Society became a mathematically vibrant landscape could be envisioned at that point.

ON THE ROADMAPS FOR DEVELOPMENT PURSUITS IN APPLIED MATHEMATICS

Rabindranath Sen
Formerly, Professor Department of Applied Mathematics, University of Calcutta
e.mail : rnathsen@gmail.com

The University of Calcutta has the unique distinction of having three separate departments, namely, dept. of Applied Mathematics, dept. of Pure Mathematics and dept. of Statistics instead of a single department. Such a development did not take place overnight. The precursor to the establishment of a department of Applied (Mixed) Mathematics was the study of application of Mathematics in the famous Presidency College which had eminent teachers. Their attitude towards developing application of mathematics inspired among others, a prodigy like Radhanath Sikder to calculate trigonometrically the height of Mt. Everest. Although Pure Mathematics was in existence in the university, Sir Ashutosh Mookerjee took the initiative in establishing department of Applied (Mixed) Mathematics in the Science College built in the house donated by Sir Tarak Nath Palit.

Applied mathematics, as the name suggests, is devoted to developing such mathematics which has a direct relevance to science, engineering, business and industry. In its early phase, the emphasis was mainly on mechanics including celestial mechanics, ballistics, quantum mechanics, geodesy and geophysics, theory of elasticity and its related subjects. Stalwarts like Prof S.K. Bannerjee and Prof. Ganesh Prasad adored the chair of Ghose Professor of Applied Mathematics respectively. Prof. Bannerjee did stupendous work on geophysics, where as Prof Ganesh Prasad, a scholar trained in Gottingen was an analyst. Dr. B.B. Dutta, also a faculty of the department did pioneering work in History of Mathematics. Apart from carrying out research in hydrodynamics, he wrote a book entitled '*The Science of Sulba*'. In this book he studied the Vedic rites of *the Agni-Cayana* (the construction of Fire-altar) from a point of view, purely secular, quite different from that of unravelling their deep mysticism and highly speculative philosophy. In the early stages of the department, Nikhil Ranjan Sen, a bright student joined the department and carried out research in the theory of Newtonian Potential and the mathematical theory of Elasticity and Hydrodynamic waves. He was awarded D.Sc. degree by the Calcutta University. Soon after, he proceeded to Europe on study leave from the University and worked at different centres of advanced study and research in Berlin, Munich and Paris. He was introduced to the famous scientists like Max Planck, Albert Einstein, Arnold Sommerfield and Louis de Broglie and others. The contact to front ranking scientists exposed him to various modern branches of Applied Mathematics and theoretical Physics. On his return to India he was appointed Ghose Professor of Applied Mathematics, Calcutta University. This led to a great upsurge in the department. Study and research in diverse branches of mathematics and theoretical physics including theory of relativity, astrophysics, quantum mechanics, statistical mechanics, MHD, fluid mechanics, theory of elasticity and ballistics were introduced. This practically marked the beginning of a systematic study and research in Applied Mathematics throughout the country. Under his able leadership the department drew national acclaim as one of the important centres of learning. Prof. Sen initiated research in plasma physics which culminated into a strong group of plasma physicists. It is to be noted that Professor M.R. Gupta, prior to his shifting entirely to Plasma Dynamics, made two seminal contributions on non-linesr dynamics such as 'Exact inverse scattering of solutaion of non-linear evolution equation in a non-uniform medium, Physics Letters, A72, 420 (1979) 'Extension of universe scattering method to non-linear evolution equation in non-uniform medium,' Journal of Mathematical Physics, 22, 2180 (1981). The group includes late Professor M.R. Gupta, Professors K.P. Das, S. Sarkar and Dr. Samiran Ghosh. Prof. N.R. Sen started a small laboratory of numerical computation for his M.Sc. students. This has led to a number of computer laboratories for students and scholars. Before his retirement he was engaged in setting up a small hydrodynamical laboratory with a small flume and a wind tunnel. Prof. A. Ghosh of ISI, Calcutta guided research scholars to perform experiments in this laboratory. At that point of time this was the first of its kind in India.

Prof. B. Sen who shifted to Jadavpur University from Calcutta University was a prolific worker in the theory of elasticity, fluid dynamics, etc. Prof. S. (Suddhodhan) Ghosh who was a brilliant teacher of the department made significant contributions in the theory of elasticity and fluid dynamics. Dr. K.M. Basu wrote many papers on theoretical physics and published them in journals of repute.

Another brilliant product of the Department of Applied Mathematics was Dr. Subodh Kumar Chakrabarty. In the initial years, he worked mainly on Cosmic Showers. But later he became the Director of Colaba and Alibag observatories in Bombay and worked there until his visit to the California Institute of Technology, Pasadena, U.S.A. as a Visiting Research Fellow. He worked mainly on Applied Geophysics and concentrated on geophysical prospecting for oil and minerals and calibration of electromagnetic seismographs. After returning to Calcutta, he worked as the Professor and Head of the Department of Mathematics in B.E. College, Sibpur, Howrah. With financial support from CSIR, he established a seismographic station at B.E. College and also maintained a small observatory in the sea beach of Digha in Midnapur. He and his group of co-workers conducted study of microseisms and sea waves and their correlation with cyclonic disturbances. In 1963, Prof. Chakrabarty joined the Department of Applied Mathematics, Calcutta University as the Rashbehari Ghose Professor. During his tenure the department was throbbing with various research activities. The UGC recognized the department as the Centre of Advanced Study in Applied Mathematics (CAS).Thus the department became one of the four centres of Advanced Study in the country. Many academicians from Soviet Russia visited the department and delivered talks. Notable among them was Prof. Alexandrov who gave a series of lectures on differential geometry. Some of our faculty members visited Soviet Russia for exchange and expansion of ideas. The department was augmented with several faculty members. Professor late A. Mukherjee, A. Roy and S. Sen of the department pursued the said subject.

The profile of a subject does not remain static. So is the case with Applied Mathematics. The next Ghose Professor, Prof. P.K. Ghosh in late seventies felt the need for updating the syllabus with the introduction of some contemporary disciplines. The aim was to give the students an exposure to one of the several optional courses and giving them an opportunity for further studies of the discipline of their choice. The subjects incorporated in the optional papers were as follows; statistical mechanics, dynamical meteorology, dynamical oceanography, operations research-II, elements of mathematical economics, elements of mathematical ecology, elements of control theory. This opened up new employment facilities. A number of pass outs joined GSI (Geological Survey of India) and IMD (India Meteorological Department) as research scientists. Some have risen to quite senior positions. B. Basu, P. Raychaudhuri, T. Kanjilal carried out good amount of research in astrophysics. Their earlier forerunners were the internationally famous Prof M.N. Saha and his contemporary Prof. N.R. Sen. Prof. S.S. De worked in ecology. The department has a tradition of teaching quantum mechanics and carrying out research in it. During the tenure of Prof. Chakraborty and later many teachers like late Prof. T.C. Roy, late Prof. J.N. Das, Prof. P.Raychaudhuri, Prof. S. S. De pursued research in quantum mechanics. B. Bagchi has been pursuing research in Quantum Mechanics, Quantum field theory, *Nonlinearity* and High Energy Physics. D. Sarkar and I. Chattopadhyay are pursuing teaching and research in quantum information and quantum computation. After the famous papers on turbulence by Prof. N.R. Sen, the tradition of pursuing fluid dynamics was maintained by teachers like Professors S. Ghosh, A. Ghosh, D.D. Mullick, A.K. Pramanik, B.N. Mandal (who later joined ISI, Calcutta), U. Basu, S. Debsarma and S. De. The department since the time of Professors N.R. Sen, N.N. Sen, S. Ghosh, and B. Sen has systematically carried out research in theory of elasticity and plasticity Names may be mentioned of late P.P. Chatterjee, J.G. Chakrobarty, S.C. Bose, P.K. Chaudhuri, M. Kanoria who pursued the said branch. C.G. Chakraborty, a student of Prof. M.Dutta carried out research in statistical mechanics and mathematical biology. C.G. Chakraborty supervised Ph.Ds in Mathematical Biology and Nonequilibrium Statistical Mechanics. Presently S. Poria is working on Mathematical Biology and Chaos Theory.

A. Gupta joined the department as a teacher soon after passing out M.Sc. and served the department till his retirement. Prof. P.K. Ghosh introduced Automata theory in the M.Sc. syllabus in the middle of nineteen seventies as a part of the special paper Cybernetics and Advanced Computer Science. The responsibility of this subject was given to A. Gupta. A. Gupta then started teaching Automata Theory first time in India. In the first year of his teaching some teachers from Benaras Hindu University attended his lectures. He taught this subject in the department till his retirement. After retirement of Prof. A. Gupta, Krishna Kundu has been teaching Automata theory. Prof. A. Gupta wrote valuable books on *Probability and Statistics* and on *Analysis* which are of great help to postgraduate and undergraduate students. Prof. D.K. Sinha, who was the last Ghose Professor of the department carried out research in various branches of Applied Mathematics and has written seminal books, such as *Basics of Non-linearities in Mathematical Sciences*, Anthem Press, UK, 2006.

In developing the theory of applied mathematics, use of abstract ideas of pure mathematics is often made. To make the basics of applied mathematics strong, Prof. P.K. Ghosh introduced teaching of Functional Analysis, Applied Algebra, Abstract Probability theory and Stochastic processes, Optimization theory, Theoretical Computer Science etc. Professor P.K. Ghosh was an erudite scholar. Apart from specialization in other branches of Applied Mathematics, he was an expert in generalized function. He wrote the Appendix *(Schwartz's theory of distributions and the theory of physically observable functions)* in the monograph entitled *Direct Analysis of Diffraction by Matter,* R. Hosemann and S.N. Bagchi, North-Holland Pub. Company, 1962. He guided research on numerical analysis in abstract spaces. His student R.N. Sen carried out research in. numerical functional analysis and non-smooth optimization. T. Chakraborty has been teaching and carrying out research in Operations Research.

Another stalwart in the department was Prof M. Dutta. He was a contemporary of Prof. P.K. Ghosh. A nonconformist Prof. Dutta had frequent differences with his authorities. But these skirmishes did not deter him from carrying out research and guidance in several branches of Pure and Applied. Mathematics. He was an. expert in theoretical physics as well. He was very much enamoured of Dr. S.C. Kar besides Prof. N.R. Sen. Dr. Kar had his doctorate degree from Germany. Dr. Kar taught him thermodynamics and statistical mechanics. Prof. Dutta very much liked the style of teaching by Dr. Kar. After serving many other institutions of repute, Prof. Dutta joined the Centre of Advanced Study in Applied Mathematics, Calcutta University (CAS) and later became its Nikhil Ranjan Sen Professor. When the CAS programme was withdrawn unjustly by the UGC, Prof. Dutta fought tooth and nail for restoration of the programme. Under his leadership the CAS sponsored the celebration of Fiftieth Anniversary of Bose Staistics and eightieth birthday anniversary celebration of National Professor S.N. Bose. DST organized at the national level this celebration and it was resolved to institute Satyendra Nath Bose Institute of Physical Sciences (SNBIPS). Unfortunately although the move was made by the CAS of Calcutta University, the institute was built elsewhere with the name: SNBIPS. Prof. Dutta also as a President of Calcutta Mathematical Society, vastly upgraded it by augmenting various academic activities.

In the next revision of syllabus, studies of wavelet theory, of dynamical systems, of fractals and chaos have been incorporated as emerging areas of applied mathematics. Besides augmenting the basics of applied mathematics, this department has focused on study and research of existing branches like mechanics of continua, fluid mechanics, quantum mechanics, plasma physics, numerical functional analysis, geodesy and geophysics, operations research, astrophysics, biomathematics, ecology etc. Thus the development plans of the department are to widen and expand study of various branches of applied mathematics within the constraints of money and space.

A GLIMPSE INTO THE PAST: THE PRE-INDEPENDENCE ERA OF APPLIED MATHEMATICS IN CALCUTTA UNIVERSITY

Bijan Kumar Bagchi
Professor, Department of Applied Mathematics University of Calcutta
E-mall: bbagchi123@gmail.com

The post graduate departments of Calcutta University were established with a view to imparting knowledge in specialized disciplines and their common goal was to achieve world-class excellence not only in teaching but also in research. With this aim in mind two separate branches of Mathematics namely Mixed Mathematics (later renamed Applied Mathematics) and Pure Mathematics were formed in 1908 under the New Regulations of Calcutta University. The University calendar shows that two different sets of question papers began to be set from that year for each discipline comprising six papers. Previously a course in Mathematics in two components A and B were taught and presumably a student had to opt for any one of them. Initially the awarded degree was a Master of Arts (M.A.) but from 1911 onwards both M.A. and Master of Science (M.Sc.) started to be recognized by the University. The University of Calcutta appointed, in 1914, Professor Ganesh Prasad as the Head of the Department and first Rashbehari Ghose Professor in Applied Mathematics. It was expected that applied mathematicians passing out from the department would acquire sufficient professional expertise to cope with the practical problems encountered in the applications of mathematics to different areas of science. The teaching of Applied Mathematics was substantially modeled on the syllabus of the department of Applied Mathematics and Theoretical Physics of the Cambridge University, UK and it was thought that the standard of examination of Calcutta University was at par with Mathamatical *Tripos.*

Ganesh Prasad was a person of exceptional talent and scholarship. He travelled to Cambridge to do research and while being there came in contact with luminaries like Ernest William Hobson and Andrew Forsyth. These mathematicians influenced him a great deal. Later he went to Göttingen to become acquainted with the German School of Mathematics. Here he picked up associations with Arnold Somerfield, Felix Klein and David Hilbert among others. During his stay in Göttingen he wrote an important paper on the *Constitution of Matter and Analytical Theories of Heat : An Essay in four Parts* which was published in Göttingen Abhandllingen in 1903.

Ganesh Prasad had a wide range of research interests both in pure and applied streams of mathematics ranging from the mean value theorems, theory of potentials, Fourier series, theory of surfaces to spherical harmonics, functions of Bessel and Lame, elliptic functions and higher transcendental. He was instrumental in giving the department the space it was looking for in the international map. In1917 he gave a series of lectures on *Poisson's equation and its failure* as part of the University's program on Extension Lectures intended for advanced students. The purpose was to create among them a desire for original investigation or research. He occupied the Ghose chair for about four years.

One of Prasad's students was Bibhuti Bhusan Datta who obtained the Master's degree in Mixed Mathematics from Calcutta University in 1914. In the same batch his two other brilliant classmates were Deba Prasad Ghosh and Sudhansu Kumar Banerjee. Banerjee later became the Ghose Professor in 1919. He also worked for sometime at the Indian Association for the Cultivation of Science on the problem of generation of sound waves by the impact of two spheres. He was a scholar of great distinction and published several noteworthy papers on meteorology. The paper on *Microseisms Associated with Disturbed Weather in the Indian Seas* published in the *Philosophical Transactions of the Royal Society, London* in 1930 deserves special mention. He however left the post of Ghose Professorship to join the India Meteorological Services of the Government of India.

Bibhuti Bhusan Datta did his D.Sc. from Calcutta University in 1920 on Hydrostatics. However at the encouragement of Ganesh Prasad he turned his interest to the subject of History of Mathematics and did some pioneering works in this field that included studies on the contributions of Ancient Hindus to Mathematics. He wrote numerous papers on the History of Mathematics which were published variously in American Mathematical Society, Bulletin of Calcutta Mathematical Society and Journal of Asiatic Society, Bengal. He was a member of the teaching staff of the Applied Mathematics department where he was concerned with the teaching of certain aspects of planetary theory. Datta resigned from the department in 1929. That even after retirement he was still active is evidenced by the fact that he gave a course of lectures in 1931 *On History of Mathematics in India* before *1600 A.D.* under a special Readership program of Calcutta University. He took *Saṁnyāsa* in 1938 to become known as Swami Vidyaranya.

The following batch of 1913-1915 had some illustrious names in its student list like Satyendranath Bose, Meghnad Saha and Ṇikhilranjan Sen. From this academic session onwards some changes in the syllabus came into force to keep up with the modern developments of applied mathematics. A look at the examination papers of 1915 reveals that the subject of Elasticity was offered in two parts, I and II. The questions of part I were set by Debendranath Mallick while those of II were set by Ganesh Prasad himself. There were also two papers on Lunar and Planar Theories the questions of which were set by Sir Asutosh Mukhopadhyay. Additionally the students had to take two papers on Spherical Astronomy. Phanindralal Ganguly was the paper setter of both the papers. Bose secured an almost unsurpassable aggregate of ninety-two per cent marks clinching full marks in one of the papers. Saha came second. Nikhilranjan Sen completed his Master's a year later. Like Bose he also secured the top position in 1916. Shortly after passing out from this department Bose and Saha were appointed lecturers in 1916 in this department itself. Sen, however, preferred to work for a D.Sc. degree which he obtained in 1921 from Calcutta University. Subsequently, he proceeded to Germany to work with the Nobel Laureate Max Von Laue at the University of Berlin. In those days Bose had an interest in differential equations, harmonic analysis and mathematical physics. Saha, on the other hand, was mainly concerned with the study of heat and thermodynamics, spectroscopy, the emerging area of Bohr's quantum theory and Einstein's newly proposed General Theory of Relativity (GTR). Bose and Saha collaborated actively between themselves and apart from writing some joint papers such as *On the influence of the Finite Volume of Molecules on the Equation of State* published in *Philosophical Magazine* in 1918 and *Energy Spectrum of an Atomic Model* published again in the same journal in 1920, also took up the formidable challenge of translating Einstein's original paper on GTR in English. This mission was successfully completed in due course and a treatise entitled *The Principle of Relativity* was published by the University of Calcutta in 1920. The book also contained Saha's translation of Einstein's first paper on Restricted Theory of Relativity (more popularly known as the Special Theory of Relativity which Einstein advanced in 1905) and Minkowski's 1909 paper on the Principles of Relativity. It carried an introduction by the celebrated scientist and applied statistician Prasanta Chandra Mahalanobis. An interesting point to note here is that while they were at the translation, Einstein's GTR was not yet verified as an accepted theory. However, on a solar eclipse day of May 29, 1919, during an expedition to the island of Principe off the West Coast of Africa, the noted British astronomer and mathematician Sir Arthur Eddington, announced the results of the deflection of light as predicted by GTR by taking the pictures of the Sun during the eclipse. Soon after this event Saha was commissioned by The Statesman of Calcutta to give a popular account of the results. Saha wrote in its November 13, 1919 edition:

> The theory of relativity was first formulated by the great Dutch physicist, H.A. Lorentz, during the closing years of the last century, but was largely recast and elaborated by Einstein, then a rising mathematical physicist of Switzerland, and Minkowski, a Russian Jew, whom persecutions of his country drove him to Germany. The generalized theory of Relativity, which has just been brilliantly confirmed, is on the other hand, the sole work of Einstein and was first formulated in the year 1911 and elucidated in a number of papers published from 1911 to 1917.

In 1918 on the basis of his works on electromagnetic and radiation pressure Saha was awarded the D.Sc. degree of the Calcutta University. Among the examiners of his thesis were Sir Owen Willans Richardson who later won the Nobel Prize in Physics for his work on thermionic emission, and Norman Robert Campbell who was a Fellow at Trinity College, Cambridge. Saha was awarded the Premchand Roychand fellowship in 1919. In the same year he got the Guruprasanna Ghosh travel grant that enabled him to go to Europe. He became a household name after his formulation of the ionization equation in 1920.

Bose and Saha did not stay at the Applied Mathematics department for long presumably because of some differences with the Head of the Department Ganesh Prasad. They shifted to the Physics department within about a year of joining the Applied Mathematics department. The Physics department at that time did not have any facility of a laboratory and so to start with they took it upon themselves the task of teaching post graduate students the basic courses in the theoretical aspects of physics. However they continued to take selected classes in the Applied Mathematics Department. For instance Bose taught elasticity and relativity while Saha taught hydrostatics there. They were also passionate about how mathematics should be taught and did not hesitate to solve any difficult mathematics problem that came their way. A story goes that once Sir Asutosh Mukhopadhyay, the great visionary whose extraordinary research accomplishments in mathematics are well known, set an extraordinarily stiff problem in the Mathematics Honors examination for three consecutive years but found to his utter surprise that not a single student could tackle it properly. He raised this issue in one of the Board of Studies meetings when Bose stood up and told him quite curtly that the problem was erroneously constructed. Sir Asutosh had no answer to Bose's point and the problem had to be recast differently. Such was Bose's command in mathematics. Bose finally left for the Dacca University in 1921 while Saha joined the Allahabad University in 1923. It was at Dacca where Bose introduced the idea of quantum statistics that ultimately gave way to the fact that all integral spin particles, the so-called bosons, obey Bose statistics. Both however returned to Calcutta and joined their *Alma Mater:* in 1938 Saha was appointed to the post of Palit Professor in Physics and in *1945* Bose joined the Physics department as a Khaira Professor.

Meanwhile Nikhil Ranjan Sen decided to return to Calcutta from Germany and in 1922 was offered the Ghose Chair in Applied Mathematics, a post he occupied continuously until his retirement in 1959. It is held that he was chiefly instrumental in creating a school of applied mathematics in India. Its influence spread far and wide and indeed, opened up a new research domain for many applied mathematicians in India. Towards early in his career, Sen worked on the problems of spherical harmonics but also made substantial contributions in many areas of applied mathematics, theoretical physics and astrophysics. For instance, he worked on the then popular subject of wave mechanics for sometime and wrote a paper on Dirac's relativistic equation. General Relativity and Cosmology was another area that interested him. He wrote many influential papers in this direction and is regarded as one of the founding fathers of research in India in this field, the other being Vishnu Vasudev Narlikar, the father of noted astrophysicist Jayant Vishnu Narlikar. Incidentally, the senior Narlikar was an external examiner of the department for many years and was one of Sen's close fiends although Sen was a few years senior to him. One of Sen's important works is entitled *On the Stability of Cosmological Models* which was published in *Zeitschrift fur Astrophysik* in 1934. It claimed that the isotropic and homogeneous models of Einstein and of Friedmann are unstable for initial rarefaction. Andrzej Krasinski observes in a recent reassessment of his work in the esteemed journal *General Relativity and Gravitation* that two features of this paper stand out to be remarkable: One is that Sen at all had the idea to consider the application of an exact solution of Einstein and the other is the near prediction of an event that was indeed observed more than forty years later. His research works also included the problems of stellar constitution and the theory of turbulence. He dedicated an important part of his time in training young research students.

Two of Sen's notable students in the thirties were Samarendranath Roy and Biseswar Datta. After passing out from the department securing the top position in 1931, Roy joined as a Research Associate to Sen to work on cosmology. But he gradually shifted to Statistics and in collaboration with Prasanta Chandra Mahalanobis and Raj Chandra Bose made some significant contributions in this area. Later he became a resident of the United States of America. He will be remembered for his lasting contributions to multivariate statistical analysis. Biseswar Datta passed out in 1934. He was very talented and impressed Sen very much. He worked in the area of GTR and in one of his papers obtained some interesting solutions of the Gravitational Equations of Relativity. He died rather young while undergoing a hernia operation in the Medical College Hospital in 1941.

Nikhil Ranjan Sen was greatly interested in the computational aspects of Applied Mathematics. To this end he started in the mid-thirties a laboratory for numerical computation. During the later part of his academic life he also set up a hydrodynamical laboratory with a flume and a wind tunnel. He started the Saturday seminar in the forties which was basically a small discussion club consisting of not more than ten researchers on the average. The main aim was to discuss a mathematical problem or to make some purposeful comment on some recently published interesting papers. In this way the younger members were motivated to pursue a research problem on their own. Bose frequently took part in such seminars.

Sen had a long and distinguished career in the Applied Mathematics department running into approximately thirty seven years. It appears that when he assumed the charge of the department he must have felt a void left by the departures of two of his classmates Bose and Saha. In contrast things were not so bad in the neighboring Physics Department where Sir Chandrasekhara Venkata Raman was holding the Palit Chair and making his presence felt with remarkable discoveries. Actually Raman was then within sight of his discovery of Raman Effect that would earn him a Nobel Prize in Physics in 1930. To recapture the intellectual life when his two friends Bose and Saha were actively engaged in both research and teaching and working with considerable glory and fame in the same department a few years earlier must have been immensely difficult for him. But Sen was not a man to be bogged down. He held his own and soon found a group of young teachers ready to assist him. They were Nripendra Nath Sen (1916-18), Kshetra Mohan Basu (1918-1820), Suddhodan Ghosh (1918-20) and Bibhuti Bhusan Sen (1919-21). All were working in some problems of continuum mechanics one way or the other. In particular Nripendranath was prolific in his research outputs: between 1922 and 1929 he published as many as eleven research papers. However, teaching was the first priority of the department. Almost all were extraordinarily good teachers

(Nikhilranjan Sen included) and students who have had the occasion to take lessons from them still remember their classes with warm fondness. Sen could at times adopt a completely critical mind but that was because he could foresee the great possibilities that lay ahead of Applied Mathematics as a subject in itself. He himself was a great example. His personal integrity to lead the department made him a role model to many of his colleagues. To quote Bose:

> *To his students and colleagues Sen was a model of single-minded devotion to work, and the team of enthusiastic teachers which he built up in his department at Calcutta was inspired by his exemplary character.... One would also often see him on holidays holding small study groups in his house, squatting on a map, reminiscent of an ancient teacher with his disciples.*

The department was very productive during his time in the sense of churning out good, scholarly students. However it must be said that being a person of a retiring temperament, he was disinclined to committee and administrative works. Perhaps because of this shortcoming he could not build up an institute of Applied Mathematics during his tenure in spite of holding many advantages. In contrast Meghnad Saha during his lifetime established the Institute of Nuclear Physics at Calcutta which later became known as the Saha Institute of NuclearPhysics after his demise in 1956. Looking back it also appears that one of his other drawbacks was that, even with two of his personal friends Bose and Saha holding chairs in the Physics department, he could not initiate a joint teaching program between the Applied Mathematics Department and Physics Department to undertake classes on common subjects like mathematical methods, electromagnetic theory, complex analysis, quantum mechanics, plasma dynamics and several others.

A few names of eminent scholars during Sen's time were Bratisankar Ray (1926-28), Sisirendu Gupta (1926-28), Samarendranath Roy (1929-31), Subodhkumar Chakrabarty (1930-32) and Biseswar Datta (1932-34). Of Roy and Datta we have already spoken. Bratisankar Ray, after taking his M.Sc. degree, went to Göttingen from where he wrote the remarkable paper on the *Eigenvalues of Asymmetric Gyro* which was published in Zeitschrift fur Physik in 1932. This paper introduced for the asymmetric top problem an asymmetric parameter that goes by his name. The paper has been copiously cited and is still relevant today. After return from Göttingen he was inducted to the Department as a permanent faculty member. Sisirendu Gupta was working in the Department under the supervision of Nikhil Ranjan Sen. In 1931 he published in Zeitschrift fur Physik a very interesting paper on the *Radioactive Decay of the Relativistic Wave Equations.* Coming as it did, close on the heels of the developments of relativistic quantum mechanics, it must be said that the scholars in this department were really working at the forefront of contemporary research. Of Chakrabarty, it is heard that Homi Jehangir Bhabha of *Bhabha scattering* fame was in look out for some dedicated, serious student who could assist him in the research problems he was pursuing. Bhabha at that time had just finished his work on Cascade theory of Atomic Showers with Walter Heitler and wanted to apply his results to specific problems. Bhabha knew that there was no dearth of talented students in Calcutta. He asked for Sen's opinion. Sen suggested Chakrabarti's name who at that time was a part-time lecturer in the Applied Mathematics department. Chakrabarti readily agreed to this offer and proceded to Bombay. Bhabha and Chakrabarti published three influential papers on various aspects of the cascade equations including rigorous derivation of their exact solutions. These papers were published in the Procedings of the Indian Academy of Sciences, Proceedings of The Royal Society, London and Physical Review. Chakrabarti also published a few papers independently. He was awarded a D.Sc. degree from the Calcutta University in 1943. He visited California Institute of Tecnology during 1947-48. This concludes a brief survey on the status of Applied Mathematics Department during the period between the two World Wars.

RECAPTURING CONFLUENCES OF INDIAN AND WESTERN INFLUENCES AS A MEANS FOR UNFOLDING SOME DIMENSIONS OF APPLIED MATHEMATICS

Dilip Kumar Sinha
Formerly, Sir Rash Behary Ghose Professor of Applied Mathematics, University of Calcutta
e.mail : dilipkumarsinha@rediffmail.com

The colonial rule having made a dent in different segments of Indian community, had to witness, somewhat uncomfortably, the formation of some pockets of semi-elitism with pro-establishment stances. The Indianness, having suffered diminutively on scores of a variety of factors, could begin responding to exposures to western stuff. Of all areas of discourses, mathematics could affordably have different complexions. The British influences had, overwhelmingly, definite edges over those of others. Even prior to the foundation of the Hindoo College, public opinions in favour of westernization were earnestly sought for by allies and new spokesmen of the British regimes. Among few upshots of the flux of history, one finds few Indians with an honestly receptive bent of attitude, pouncing on new ideas. A select few decided to go abroad, with risks invariably from the society; some, dominantly aspired for interactive modes, often on this area and certainly, with inspirations available from good souls here and from abroad. That sort of open-minded approach allowed itself to grapple with what British institutions could offer. The French influence had its sway, as is pronouncedly evidenced by Asutosh Mukhopadhayay's works. Geometrical pursuits, could have an intrinsic stay on him and that from, France. Asutosh did not at all shy away from purists in other parts of Europe. His papers on Clebsch's transformation and Stokes theorem *vis a vis* hydrokinetics bear a good testimony to that. His dabbling with physical and mathematical sciences in the IACS at Bowbazar, shows his keenness to push mathematical elements in areas, amenable to mathematization. Ramanujan's seemingly stray ventures, initiated from a British text, reached out to mathematically innovative zones, also called for western interaction, followed legitimately by an interactive phase in England. There could hardly been any such defining moments, hadn't the westerners been enamoured of Indian moorings in mathematics. A rational choice could scarcely be possible at that point of time. But that western mathematics, more so in applied mathematics, needed to be seriously and voraciously seized of as a part of sustainable mathematical activism that could rapidly become a *sine qua non* of the mathematical community. Any conspectus on the works of Indian research in applied mathematics shows not only apposite sequels, in no way derivative-extensions, but in-depth investigations into problems. Fluid dynamics seemed to be an obsessive exercise in that even abstracts of research papers evinced impeccably mathematical concepts of the work, which seldom left in the lurch, any interwoven canopy on physical reality, mathematical reality in their possible aspects and, of course, the interpretation. Works on solid mechanics didn't go by default; seismology, geophysics, and geodetics were well within the ambits of applied mathematics.

As is well-known in mathematical realms, consolidation is resorted to so that shortcomings, if any, can be plugged in. A series of papers and/or the theses of N.R. Sen, B.B. Dutta, S.K. Banerjee, N.N. Sen, S. Ghosh, B. Sen formed the mainstream that should be delved into so as to contextualize the reality of applied mathematics in the first and second decades of the last century. The publications in Bulletin of Calcutta Mathematical Society or Philosophical Transactions of Royal Society or Philosophical Magazine, incontestably showcased the excellence of the works in those days. S.N. Bose and M.N. Saha (along with K.M. Basu), of course, carved out new areas, close to theoretical physics that haven't even now, been missed in definite neighbourhoods of Cambridegean pursuits on applied mathematics. Seeking a new perspective in terms of diversity seemed to be on the anvil. The initial leadership, as history says, under Professor Ganesh Prasad, the first Sir Rash Behari Ghose Professor of Applied Mathematics, having an academic stint at London, did not seem to be well equipped for a possible turnaround. Perhaps, there being no institutional agenda and at the same time, because of genuine simmerings among the younger people, Professor Prasad had to stay away from the leadership for few years; he did come back to the precincts of Calcutta University as Hardinge Professor of Higher Mathematics. Bose and Saha left the citadel of the University College of Science. But their joint papers in Philosophical Magazine (1918) and Bulletin of Calcutta Mathematical Society (1920) have to be reckoned with; the papers dealt essentially with thermodynamics. The Bulletin of Calcutta Mathematical Society saw in (1919) two papers of Bose on elasto-dynamics, part of which he used to teach to budding applied mathematicians, in those days, like S. Ghosh and B. Sen. N.R. Sen joined the department in 1917 and his paper on Newtonian potential came out in Bulletin of Calcutta Mathematical Society, along with others on Elasticity and Hydrodynamics in Philosophical Magazine. His in-depth researches on elastic waves, with isotropic/non-isotropic characteristics led him to establish, in conclusive terms, trajectories of wave propagation in elastic media and more so, in terms of demarcations of energy in perturbed *vis a vis* unperturbed areas. And that came out in the Bulletin of Calcutta Mathematical Society in early thirties of the last century. Philosophical Magazine (1924) saw several papers of N.R. Sen, for example, on elastic shell and more conspicuously on long wave propagation, considering geometrizations of canals concerned.

Any historical sweep from 1910 and the next decade, too, provides few revelations of bedrocks as from western influences in areas of applied mathematics. Although B.B. Dutta had his Master's degree in 1914, he had his mathematical debut "On a physical interpretation of certain formula in the Theory of Elasticity', published in Bulletin of Calcutta Mathematical Society (1910), Vol. 2, No. 2. Dutta, to his pupils, stood out as an exemplar of a teacher intensely absorbed in mathematical studies (of the applied brand) yet kept on equipping them with the ability to reach out to other mathematically challenging areas. His engagement with Hydrodynamics seemed to have kickstarted, as a student of M.Sc. in Applied Mathematics; otherwise, his another paper 'On the Figures of Equilibrium of a Rotating Mass of Liquid' would not have seen the light of the day, vide, Bulletin of Calcutta Mathematical Society (1918), Vol. 2, No. 1, Dr Dutta joined as a faculty member of Applied Mathematics department in 1917 and earned the reputation of being a brilliant teacher. His course of lectures on 'Lunar and Planetary Theory', shows, in no uncertain terms, the practice of the Department to offer courses not at all included in the prescribed syllabus at the postgraduate level. S.K. Banerjee, his contemporary, joining the Department in 1918, worked on elasticity and fluid dynamics. Professor S.K. Banerjee, mainly on the recommendation of Sir Gilbert Walker, Director Genereal of Observatories, joined the Survey of India, leaving the post of Sir Rash Behary Ghose Professor of Applied Mathematics in 1922. Although Dr. Datta lamentably left for hermitage, he did not leave mathematical pursuits, rather allowed himself to be assiduously engrossed in seminal studies on history of Indian mathematics. That Dr. Dutta did not dispense with his *forte* of mathematics could be glimpsed through his course of lectures on *Sulva Sutras,* a few years later, in the premises of the University of Calcutta.

It would be highly inappropriate if the names A.C. Banerjee, B.M. Sen, S.C. Kar and H.D. Bagchi are not mentioned. All of them except one had their exposures abroad and kept themselves associated with the Department of Applied (Mixed) Mathematics in one way or the other, of course, essentially as a teacher. H.D. Bagchi continued for years in the Department of Pure Mathematics of Calcutta University. S.C.Kar, although formally a Professor in Bangabasi College, remained attached to the Applied Mathematics Department for a pretty long period. His erudition became a legend in the mathematical ambience of the university. Dr. Dutta declined the post of the Ghose Professorship in the Department. N.R. Sen went abroad and, in fact, to Germany, to work with Von Laue at Berlin University. Expectedly, he had opportunities for several interactive modes with leading figures in Germany, in facets of applied mathematics and physics. He came back and joined as Sir Rash Behary Ghose Professor of Applied Mathematics in 1924.

Professor Sen's assumption of the post preceded by his return from Europe, and being well in the know of mathematical happenings abroad was, in a way, a precursor of shifts in paradigms pursuits in the department. Instead of being explicit, queries on what ought to be applied mathematics is all about and who the applied mathematicians are, kept on having a sort of a dilemma and continuing so at least, in all abodes of applied mathematics.

Positively speaking, yearning about seeking innovative perspectives of applied mathematics remains virtually relentless. Asutosh Mookerjee, as a Vice Chancellor, could steal a march over others elsewhere, in commissioning Professor W.H. Young to submit a report on the Study of Mathematics in Europe. Unfortunately, neither Asutosh nor Young could have any opportunity to interact with each other on the findings of this report. Here is a report which could have been a vademecum for the then applied mathematics department. There was no interactive feedback, as it saw the light of the day, first in 1976, and later now, on the occasion of 150th birth anniversary of Sir Asutosh Mookerjee. Much more revealing, perhaps, a distinctive mandate, in terms of the jargons of the day, was the anthology of the addresses that Sir Asutosh Mookerjee delivered during his tenure as Vice Chancellor of the University. As conjured up later on by Dr. Nripendra Nath Sen of the Department, he was almost being prevailed upon to go abroad and to acquire something what could have been researched in the department; in passing, one ought to say that Nripendra Nath Sen's expertise in fluid dynamics was mentioned in a Convocation address by Sir Asutosh. In other words, Asutosh Mookerjee, undoubtedly ranged himself in favour of developing what may be called intellectual kinships in mathematical arena and more so, in applied mathematics. The sojourns of Professor N.R. Sen in Berlin, Munich and Paris in different sites of mathematical vis a vis theoretical physics ambiences could decisively trigger off reinforcements of new vistas of applied mathematics in the department, if not in Indian setting. The Annal der Physik, in those days, saw his papers on general relativity, without being able to foresee what marks they would have fetched in terms of current benchmarks. His papers in Zeitschrift fur Physik also testify to his deft mathematization on masses and Lorentz numbers, in particular. As a follow up, the curriculum in Applied Mathematics could be cast afresh. Obviously, studies in Mathematical Theory of Electricity & Magnetism could get a new fillip and dimensions, as well. Confluences of minds and approaches seemed to be then very much in the air. Even though Satyen Bose had left for Dacca University and M.N. Saha for Allahabad University, N.R. Sen was the lone figure in the portals of the University College of Science. Competitive traits in approaches to teaching and research became discernible. For example, for that in Electricity and Magnetism, as found in those days, was not an arbitrary mix up but a generic coupling of thought processes of the British school and the European school. B.S. Ray, having been reared up, for his doctoral work, in Gottingen University used to be at home, when he drew upon works and notes of Courant and Max Born. Not often deftly, his classroom presentations were meant for turning attention towards European classics and modern works, as well whether they be in German or French. By the way, a foreign language other than English, was not an impediment to mathematical acquisition for members of the faculty. S.C. Kar kept himself dominantly aligned with the German School and so he, ideologically, insisted upon Sommerfield, Planck, besides those mentioned above; for any exposure on Electromagnetic Waves and Optics etc. B.M. Sen, genuinely belonging to the British school, opted for James Jeans in instructional exercises on Electricity and Magnetism. N.R. Sen, could bring about a coupling of both the trends, as evidenced by his work on General Relativity theory when Einstein's unified field theory could be ventured upon by him using Maxwellian ideas and certainly, those of Einstein.

The joint work of M.N. Saha and K.M. Basu, whether at Calcutta or at Allahabad, show mathematically viable kindred points of view, initiated by Bose, Saha and Sen. That can also be said about for the joint work on cosmic radiation of Homi Bhaba and Subodh Kumar Chakravarty. Quantum theory / mathematics did not miss the receptivity of mathematical quests in the Department. That Sen and Saha's envisioning Applied Mathematics, as an invariably useful instrumentality led to the foundation of River Research Institute is fairly well known and that, too, under the leadership of N.K. Basu, another fluid dynamicist with an academic spell at a German University. No impression should be allowed to grow, in such contexts, that European endeavours were resorted to only to have an enlightened flavour, or even an elitist stand on mathematics. Hadamard, Courant, Valee Poisson and Poincare, all from France, David Hilbert from Germany, PAM Dirac of England, Enrico Fermi of Italy used to figure conspicuously in academic parlances of the department of applied nathematics of Calcutta University. The issues and concerns on rational choice of topics and themes have had their trajectories, mostly nonlinear and so, evolutionary in terms of characterization. S.K Banerjee's holding the reins of Meteorological Department of Government of India. could well facilitate not only of his brilliant works of mathematics of Himalayas, but roping in budding applied mathematicians in realms of seismology, aeronautics, meteorology and survey studies.

The delineation in the above lines, does in no way present any mathematical landscape where applied dimensions could become bereft of mathematics *per se*. The reality was entirely otherwise. N.R. Sen, even when grappling with problems on solid / fluid mechanics kept on looking for a mathematical representation (s) in terms of an integral a series (even trigonometric or hypergeometric), not as an exercise in its own right but something that could shed an interpretation in terms of realities, physical or otherwise. Later on, S Ghosh came up, uniquely, with another representational form in terms of a complex / analytic function for problems on elastic torsion. That's the contribution which Muskellishvilli of the then USSR, had to refer to, in his classic work on elasticity. That was definitely a phase when the upshots must have been of use in developing mathematical linkages with mathematical enterprises in the erstwhile Soviet Union, in later years.

CENTRE OF ADVANCED STUDY AND DSA SPECIAL ASSISTANCSE PROGRAMME

Arabinda Roy and Susmita Sarkar***

*Formerly Professor Department of Applied Mathematics, University of Calcutta.
E-mall: arabinda1@yahoo.com

**Professor Department of Applied Mathematics, University of Calcutta.
E-mall: susmita62@yahoo.co.in

The objective of Sir Asutosh Mookerjee initiating the post graduate departments in Calcutta University was the 'advancement of learning'. In pursuance of this noble objective of the great visionary, the University of Calcutta kept the march of progress and followed various recommendations of Saddler Commission constituted in 1919 and the University Organization Committee constituted in 1928. Following guidelines of several committees, a healthy tradition was developed in the University for proper development of the postgraduate departments providing adequate facilities to the teachers and advanced students for carrying on original research in their respective fields. A close cooperation also developed between the post graduate departments and affiliated colleges.

After independence in 1947, Government of India made some generous contributions towards the development plans of the University. **University Grants Commission (UGC)** was set up in 1956 for coordination, determination and maintenance of standard of university education. University Grants Commission, on the advice of a committee formed by eminent educationists and scientists recommended to establish a Centre of Advanced Study in Applied Mathematics at Calcutta University with the Department of Applied Mathematics as its nucleus. This was the first Centre of Advanced Study in Applied Mathematics in India. The Centre of Advanced Study in Applied Mathematics started its functioning in 1964 with financial support from University Grants Commission.

From the beginning of the Applied Mathematics Department, its teachers and alumni were actively involved in original research with significant contributions to the different branches of Applied Mathematics, particularly in Mathematical Theory of Elasticity, Fluid Mechanics, Astrophysics, Quantum Mechanics, Relativity, Cosmic Ray Physics, Geophysics and Functional Analysis. Several important results of them were quoted in standard literature.

After inception of the Centre of Advanced Study in Applied Mathematics, teachers and research fellows attached to the Centre combined those subjects in groups and formed schools of research in i) Elasticity and Plasticity ii) Fluid Mechanics iii) Geophysics iv) Quantum Mechanics v) Functional Analysis and Operations Research.

As a part of the activity of the Centre, regular seminars were held in the department twice a week on different fields of study where current important research works were presented and discussed. One of the most important activities of the Centre was Physico-Mathematical

G-146114

Colloquium. In this Colloquium special lectures were delivered by experts of the Applied Mathematics department and experts of other Universities and Institutes.

The Centre regularly organized Symposia, Summer Schools and training programmes to build up trained manpower to carry on the projects they had undertaken.

During May-June 1965, a summer school in Geophysics was organized at the Central Seismological Laboratory in Shillong in cooperation with the India Meteorological Department. Twenty four experts from different fields of seismology in different parts of the country attended the summer school. Only current research problems in seismology were discussed.

A Summer School for a period of six weeks was organized in May-June 1966 at Calcutta. Special courses of lectures were delivered and discussions were organized in different branches of Applied Mathematics namely (i) Elasticity and Experimental Stress analysis. (ii) Geophysics and (iii) Methods of Applied Mathematics. Sixteen scholars from different parts of the country attended those courses.

A Summer School for N.S.T.S. scholars was organized in May-June, 1968 at Calcutta under the request of N.C.E.R.T.

In December 1968, a Symposium on Geophysics was held for one week where 28 experts in the field of Seismology took part. Dr.G.C.Chatterjee, Director General of the Geological Survey of India, delivered Special address on 'Role of Geophysics in Geology'.

In the visiting scientist program of the centre Dr. L.N. Rykunov, Department of Physics, Moscow University, worked at the Centre during August-December, 1963 on 'Microseisms and their relations with cyclonic storms'. He delivered four lectures on Microseismic waves. Dr. A.D. Alexandrov, Rector, Leningrad University visited the Department during December, 1964-January, 1965. He delivered twelve lectures on the 'Geometrical Methods in the Theory of Partial Differential Equations'. Professor M.A. Aizerman, Director of Laboratories, Institute of Automatics and Telemechanics, Moscow,delivered seven lectures on 'Problems on Automatic Control Theory, Stability of Regular Systems and Optimization', between January 7-19, 1965.

Professor Jai Krishna, Director,School of Research and Training in Earthquake Engineering, Roorkee, delivered six lectures on 'Earthquake Engineering and Design of Earthquake Resistance Strucure', during November 8-13, 1965. Professor G.S. Ramaswami, Director, Structural Engineering Research Centre, Roorkee, delivered six lectures on. 'Modern Methods in the Analysis of Shell structures and Experimental Stress Analysis' during January 17-22, 1966. Dr. H.M. Iyer, Scientific Officer, Atomic Energy establishment, Trombay, delivered six lectures on 'Instruments and Techniques in Modern Data Analysis with Applications to Normal Oscillations, Nuclear Bomb Detection and Earthquake Source Mechanism' during March 21-26, 1966. Professor W. Olszak, Director of the Institute of Fundamental Technical Research, Polish Academy of Sciences, delivered three lectures on 'Modern Developmnts in the theory of Plasticity' during May 6-8, 1966. Professor P.L. Bhatnagar, Head, Department of Applied Mathematics, Indian Institute of Science, Bangalore, delivered three lectures on 'Some problems in Magnetohydrodynamics and Plasma Physics' during June 1-4, 1966. Dr. E.A.

Hartee, University College of Swansea, delivered one lecture on 'Quasi Stellar Objects and Their Significance' on December 5, 1967.

In the second phase of the Centre (1969-74) Professor R.S. Misra of Benaras Hindu University, Dr. N.D. Sengupta of BARC,Trombay and TIFR, Bombay, Prof. S.D. Nigam of IIT, Madras, Dr. K.R. Unni of Matscience, Madras and Prof. A.K. Gayen of IIT, Kharagpur and others visited the Centre and delivered lectures on different areas of specialisation.

The department had a fluid dynamics laboratory with a small wind tunnel and a flume for studying flow patterns which was established by Professor N.R. Sen before his retirement in 1959. Under the initiative of Professor S.K. Chakraborty, a geophysical laboratory also set up as one of the standard stations of the world network of stations sponsored by United States Coast and Geodetic Survey (U.S.C.G.S). The central Geophysical laboratory was situated within the campus of Bengal Engineering College. The data obtained at this Centre were supplied to the World Data Centre and the Centre had access to the data of all other World Centres through the Data Centre.The Department used to receive regularly seismological data from (i) the Seismological laboratory of the California Institute of Technology, Pasadena (ii) the U.S.Coast and Geodetic Survey, Washington and (iii) the International Seismological Centre, Edinburgh.

Under the advice of an expert committee the Centre was selected for assistance under the Expanded Programme of Technical Assistance of the UNESCO. Under this program two visiting Professors came to the Centre from the U.S.S.R. and two of the teachers of the Department went to the U.S.S.R. for special training. Some equipment were also received from U.S.S.R. under this programme. A field station for specialized study of Microseisms and their correlations with cyclonic disturbances was set up near Digha sea beach in the laboratory of River Research Institute. The objective of this laboratory was to obtain continuous recording of wind speed, height and period of ocean waves. A set of Kirnos seismographs was received under this programme and was set up after necessary modifications at the Microseismic Field station at Digha for continuous operations. This programme being not work upto the expectation was discontinued beyond 1967.

The library of the Applied Mathematics department is one of the richest libraries in Calcutta University because of the valuable books and journals purchased from the grant of the Centre of Advanced Study. In first five years of the Centre, 695 books and thirty two research journals on its thrust areas were purchased for the departmental library from the grant provided by University Grants Commission for the Centre.

UGC sanctioned one Professor post, three Reader posts and one lecturer post for the Centre. Three Senior Research Fellowships (Rs. 500/- p.m.), six Junior Research Fellowships (Rs. 300/- p.m.) and six Research Fellowships (Rs.250/- p.m., two to be appointed every year) were also sanctioned. The scholars of the Centre were eligible to choose any field among its thrust areas. They could register themselves for D.Phil or D.Sc of the University of Calcutta.

After five years in 1969, the Centre of Advanced Study submitted a report to the UGC regarding its activities during 1964-69. After assessment of the activities UGC extended financial support for another five years upto 1974. The Government of West Bengal also agreed to bear the responsibilities for the recurring expenses of the Centre after 1974.

The development of the Centre with financial support from UGC continued for ten years upto 1974. In 1974, an Assessment Committee was constituted by the UGC to assess the activities of the Centre. The financial support from UGC was discontinued w.e.f 01.04.1974 for reasons best known to the committee at that point of time.

The academic activities initiated during 1964-74 in the Centre of Advanced Study were continued with limited support from the Government of West Bengal. In 1987, UGC again constituted an expert committee to assess the activities of the Department for possible support from the UGC under the Special Assistance Program. The committee consisted of the following experts:

1. Prof. H.C.Khare, Allahabad University.
2. Prof. Phoolan Prasad, IIsc, Bangalore.
3. Prof. S.K. Trehan, Punjab University, Chandigah
4. Dr. C.P. Srivastava, Deputy Secretary, UGC.

The expert committee visited the department of Applied Mathematics, Calcutta University on 10th February, 1987. The committee met the Vice-Chancellor, Pro Vice-Chancellor, Head of the Department, Prof. A. Mukhopadhyay and the faculty members. They discussed about the past performance, present research activities and future research plan of the department. Keeping in view the activities and achievements of the department of last ten years i.e. from 1974 onwards, the Committee strongly recommended for the restoration of financial assistance to the Department as a Centre of Advanced Study in Applied Mathematics.

UGC accepted that recommendation and approved the status of the Centre of Advanced Study to the Department of Applied Mathematics, Calcutta University with effect from 13th February, 1988. The financial assistance to the Centre of Advanced Study was from UGC, Special Assistance Program. Prof. A. Mukhopadhyay was appointed Coordinator of the Centre by the University on 19th August, 1988. In this phase of the Centre one Professor post, four Reader posts, two Research Associates and two Junior Research Fellowships were sanctioned by the UGC. For Professor and Reader posts it was proposed that these posts would be filled up after receiving the commitment from the Government of West Bengal to assume the financial responsibility for these posts after the end of the term of the UGC Special Assistance. The Centre approached State Government in this matter but it did not materialize. In this phase a part of the room of the hydrodynamical laboratory was re-modelled and handed over to the department. Unfortunately Prof. Mukherjee passed away in December 1990. Professor D.K. Sinha took over the charge of the Centre. He joined Visva-Bharati as Vice-Chancellor in June 1995. In 1998 UGC recognized the Department as a Department of Special Assistance (DSA). From then on Applied Mathematics department is receiving financial support from UGC as a DSA department. Presently its Phase-III is running.

Inputs for the above are from (i) Centre of Advanced Study in Applied Mathematics: Retrospect and Prospect (1969). (ii) Centre of Advanced Study in Applied Mathematics: Year Book (1971). (iii) progress Report of Centre of Advanced Study in Applied Mathematics (13th February, 1988 to 31st March, 1989).

HYDRODYNAMIC LABORATORY— APPLIED MATHEMATICS DEPARTMENT, CALCUTTA UNIVERSITY

Pradip Bhattacharyya* and Ambarish Ghosh**
*Formerly Deputy Director, National Metallurgical Laboratory, Jamshedpur.
E-mall: bhattacharyya.pradip9@gmail.com
**Formerly Professor, Indian Statistical Institute, Kolkata.
E-mall:

India has a long and venerable tradition in mathematics. Its most basic and influential contribution was the place-valued decimal number system, but there is much more to the story of Indian mathematics than that, especially following the recovery of Indian intellectual life in the second half of the 19th century. Under British governance, universities were established in Calcutta, Madras and Bombay in 1857. Calcutta University was fortunate in having an especially insightful and sympathetic Vice-Chancellor, Sir Asutosh Mookerjee, who was himself profoundly interested in mathematics. Although he was a lawyer by profession, he found time to publish a few papers of his own on algebraic curves and differential equations. When he was appointed Vice-Chancellor of Calcutta University in 1906, Mookerjee was determined to encourage research and support the best mathematicians that could be found. Not only did he bring such talented Indian mathematicians to Calcutta as S. Mukhopadhyay and N.R. Sen, he was instrumental in helping to establish the Calcutta Mathematical Society in 1908.

The year 1914 which saw the outbreak of the First World War was a turning point in the history of Calcutta University and Science in India. It was the year which witnessed the establishment of Calcutta University's University College of Science. No other department of University had brought it so much lustre and fame as it did within two decades of its foundation. Despite the fact that the Presidency College at Calcutta witnessed great scientific research by Jagadish Chandra Bose and Prafulla Chandra Ray in the last decade of the nineteenth and first decade of twentieth century, organized scientific research at Calcutta University began with the establishment of its University College of Science in March 1914. A galaxy of Indian scientists joined the Chairs set up with the endowments donated by Taraknath Palit and Rashbehary Ghose, both associated with the National Education Movement in Bengal since the Indian Universities Act of 1904-5 and the partition of Bengal in 1905. The holders of the Chairs often worked under great financial constraints and with whatever apparatus was locally available in Calcutta. Yet their scientific research was soon to put Calcutta University on the map of world recognition. The science that developed at the Calcutta University in colonial India was not a colonial science, as it was hardly supported by any large scale imperial funds and was solely meant for the promotion and diffusion of scientific and technical education and the cultivation and advancement of science, pure and applied, among Indians. The establishment of the College marked the beginning of a hectic period of scientific research.

The Department of Applied Mathematics of Calcutta University is one of the most distinguished Departments ot Mathematics in India and has a long and rich tradition ot its own. The Presidency College, Calcutta had a previous affiliation with the University for M.A. and M.Sc. courses in Mixed Mathematics. Dr. Ganesh Prasad was appointed as the first Ghose Professor of Applied Mathematics and Head of department from 1914-1919, and then left to join the post of the Hardinge Professor of Higher Mathematics and held this post till 1935, when he died. Prof. Prasad who started his work at Cambridge and finished it at Gottingen was mainly concerned with the potencies of ellipsoids of variable densities and attracted a number of talented students from different parts of India to do research specially in the Theory of Functions of a Real Variable. Prof. S.K. Banerjee was appointed the Ghose Professor in 1919 and was succeeded by Prof. N.R. Sen.

N.R. Sen was picked up by Sir Asutosh Mookerjee for a teaching position in the Applied Mathematics of the Calcutta University in the year 1917. Sen was a contemporary of two other distinguished scientists of the future: Satyendra Nath Bose and Meghnad Saha at the Presidency College, Kolkata. In 1913 all three passed their B.Sc. examination with honours in mathematics, Bose standing first, Saha second and Sen third in order of merit. For his academic career and research Sen opted for applied mathematics and theoretical physics. In 1921 he was awarded his first doctorate (D.Sc.) by Calcutta University, while holding a teaching position at the University's Applied Mathematics department. Subsequently he took study leave to visit and work at some of the well-known centers in Europe. His researches under Prof Von Laue on General Relativity (GR) and cosmogony brought him a second doctorate (Ph.D.) from Berlin University. In Europe Prof. Sen had the benefit of coming in contact with the leading physicists of the day including Max Planck, Albert Einstein, Arnold Sommerfeld and Louis de Broglie. Returning to India in 1923, Prof. Sen was appointed to the Rashbehary Ghose Chair of Calcutta University. General Relativity came to India through the works of two applied mathematicians, Nikhil Ranjan Sen at Calcutta University and Vishnu Vasudeva Narlikar at the Banaras Hindu University. Several young researchers joined Prof. Sen's school and emerged well-qualified applied mathematicians and relativists and soon Calcutta became an active center for fundamental research in various disciplines of mathematical studies such as Relativity, Astrophysics, Geophysics, Quantum Mechanics, Statistical Mechanics, Hydromagnetics, Fluid Dynamics, Elasticity and Ballistics. The University of Calcutta was the first organization to start the teaching of Theoretical Ballistics in India. A large number of research papers were published by the research section during forties and fifties. The works of Prof. Sen and his students on Relativistic Cosmology and Stability of Cosmological models had received international recognition. S. Ghosh's method of solving a general class of elastic problems through the use of complex functions, B.B. Sen's certain solutions of elastic problems and S.K. Chakrabarty's researches on Cosmic ray, had received considerable attention in abroad and were highly appreciated.

Prof. N.R. Sen was the longest serving (1923-1959) Head of Applied Mathematics Department and developed Numerical Laboratory and Hydrodynamic Laboratory which were extremely useful for computational and experimental studies respectively for students, researchers and academia. In 1936, Prof. Sen made an improvement in his department by the addition of a Mathematical Laboratory (Numerical analysis including laboratory work). Setting up of Numerical Laboratory indeed called for clear vision towards future scientific trend and need, which we certainly realize at present, though it did not really involve a big investment at that time. But procurement of equipment and arrangement of land for setting up of a hydro-dynamic laboratory required professional acumen and involved quite sizable amount during fifties. For consolidating the study and research in Fluid Dynamics, Prof. Sen had undertaken, with financial grant from the Ministry of Education, Government of India, the construction of a Flume and Wind Tunnel and completed installation of the Flume and nearly completed the same for the Wind Tunnel. Generally, the behavior of rivers is modeled through the use of artificial rivers-flumes-through which water can be pumped at varying rates over a variety of carefully graded sediments. River problems are very intricate and require scientific investigation and research in a laboratory with a view to arriving at correct solution before actually launching a scheme, which is generally very costly. The Numerical Laboratory and also the Hydrodynamic Laboratory are monuments of Prof. Sen's vision—rightly he had since been described as "the Father of Applied Mathematics in India".

The hydrodynamic laboratory had as main features:

1) One tilting flume, 12 meter (approx.) long having 40cm x 40cm cross-section.
2) One large wind tunnel, specially designed for study of turbulence with a 1m x 1m test section.
3) One small wind tunnel with 40cm x 40cm test section.

The flume and the smaller wind tunnel (Photo 1) were in a working condition. As regards the large wind tunnel - the body of the tunnel was complete, the propeller and the big motor were ready for mounting but Prof. Sen could not install it before his retirement. For some unknown reasons, the subsequent Heads of the Department could not complete the installation.

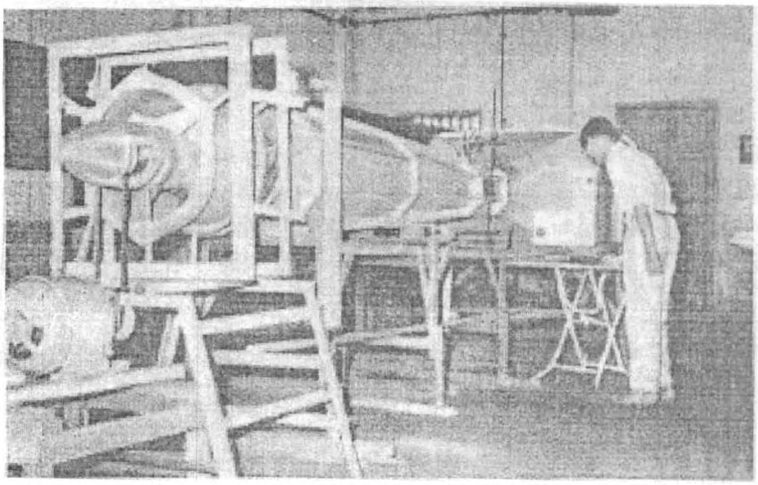


Photo 1: Small wind tunnel in the Hydrodynamic Laboratory used to study flow characteristics.

Then Prof. Suddhodan Ghosh was appointed Ghosh Professor and Head of the Department (1960-1962) and succeeded by Prof. Subodh Kumar Chakraborty (1963-1974). In 1964, Prof. S.K. Chakrabarty asked Dr. Ambarish Ghosh, an ex-student of the Department and then working at the Indian Statistical Institute (ISI), Calcutta to join Applied Mathematics Department as guest lecturer and teach the special paper on turbulence and also to set up a few simple experiments for demonstration to the students at hydrodynamic laboratory. Earlier, in 1956, Ambarish Ghosh was awarded a French Govt. scholarship to do research work in France and on the advice of Prof. N.R. Sen and Prof. S.N. Bose, joined the Institute of Fluid Mechanics at the University of Aix-Marseille, France and got his degree Dr eS Sc from the University for his work on unsteady boundary layer. Dr. Ghosh joined the Department in 1964 as a guest lecturer and continued to teach till 1995 when he retired.

In hydrodynamic laboratory, simple experiments which were planned by Dr. Ghosh to demonstrate to the students were:

i. Poiseuille flow through pipes.

ii. The famous dye experiment of Reynolds for finding critical Reynolds no. for circular pipe.

iii. The measurement of boundary layer thickness on a flat plate placed parallel to a flow and locate the point of transition from laminar to turbulent boundary layer.

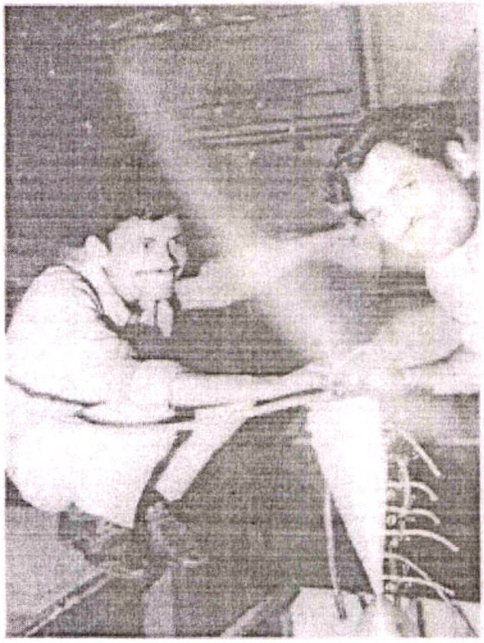
iv. The use of Pitot tube for measurement of velocity in a wind tunnel and flume.

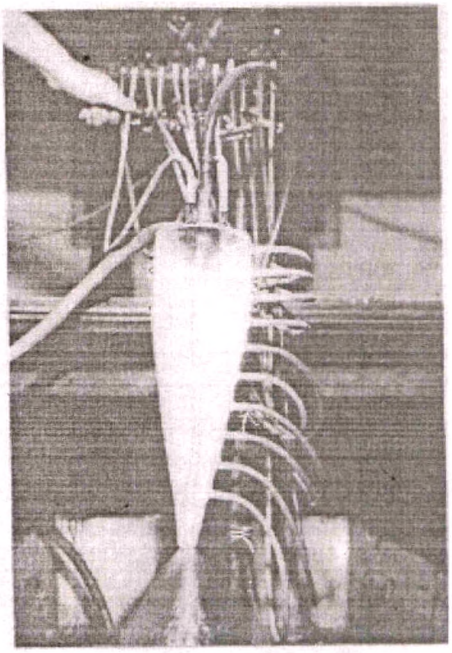
v. How the vortex streets are formed from boundary layer separation behind flat plate etc.

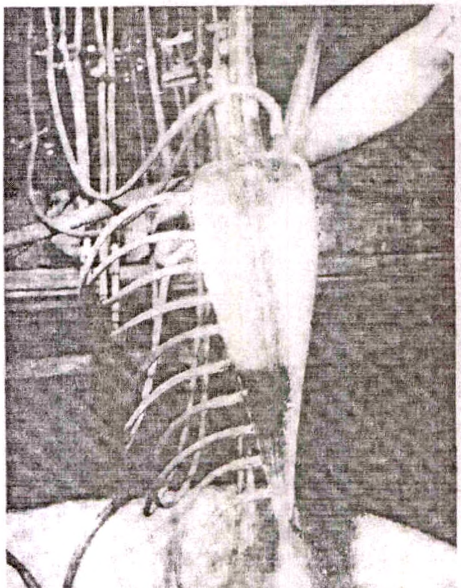
The flume and the small wind tunnel were used for these experiments. Some of the above experiments were set up and used to be demonstrated by Dr. Ghosh to the students. Since this was not included in the syllabus, students lost interest in experimentation.

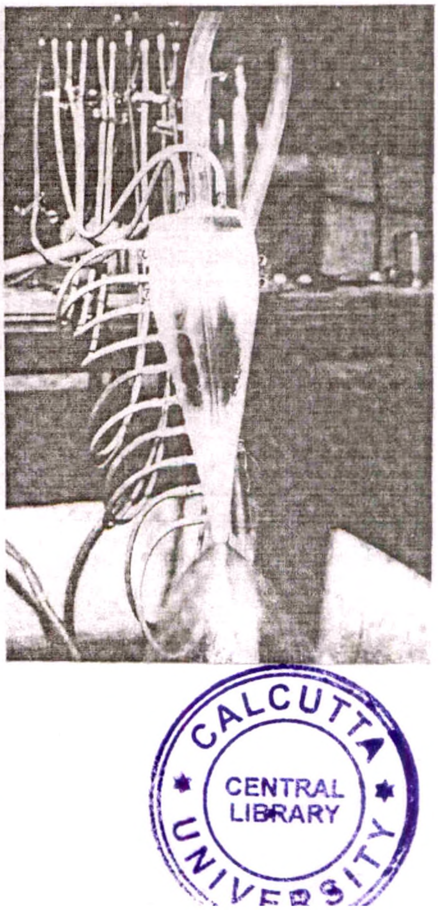
When Prof. Parimal Kanti Ghosh became the Head of the Department in 1974, he asked Dr. A. Ghosh to use the Hydrodynamic Laboratory for research work with his scholars working for Ph.D. Accordingly, two research scholars of ISI under Dr. Ghosh initiated experimental work— S.S. Chhatait, on sediment transport problem, specially the effect of surface waves on sediment transport using the flume and Pradip Kumar Bhattacharyya, an ex-student of the Department, on the flow field inside hydrocyclone after creating a new experimental set up besides the flume— at the Hydrodynamic Laboratory. A.K. Chatterjee of Hydraulic Studies Department of Calcutta Port Trust, who was working for his Ph.D. under Dr. Ghosh, helped in carrying out experiments on sediment transport. Flume studies continued several years and lots of data were collected and analyses were carried out. Though results were not readily available in the form of research publication, few technical reports of ISI were produced.

Incidentally River Research Institute established in 1943 had its first flume at Haringhata Central Laboratory (HCL), Mohanpur Nadia during sixties. An indoor hydraulic laboratory was built at Haringhata to house one fixed flume, one tilting flume and one wave flume. Important hydraulic studies were done in this laboratory as required from time to time. Flume laboratory of Indian Statistical Institute (ISI), Calcutta came up during seventies and flow field inside









CALCUTTA UNIVERSITY
CENTRAL LIBRARY

hydrocyclone, Dr. Bhattacharyya developed similar experimental facilities, as were created in the hydrodynamical laboratory, in the Flume laboratory of ISI. But Dr. Bhattacharyya had to leave ISI for higher studies abroad.

Afterwards Dr. Bhattacharyya extended his experimental studies inside hydrocyclone in the Marine-Mining laboratory of Mining Engineering Department of Delft University of Technology, The Netherlands on conventional hydrocyclone and also in the Mechanical Engineering Dept. of Southampton University, UK on Southampton University light phase hydrocyclone. Dr. Bhattacharyya studied flow field both theoretically, using central computer system of Delft University & Southampton University, and experimentally. In Delft, Dr. Bhattacharyya worked with Perspex hydrocyclones with variable length of vortex finder designed by Bhattacharyya and fabricated at the workshop of the university. Results were presented in the 2nd International Conference on "Hydro cyclone" held at Bath, England (1984) and published in its Proceedings. Photos (6&7) show experimental set up and arrangement of photographic observation of flow field inside hydrocyclone for flow visualization studies at the Marine-Mining laboratory of Mining Engineering Department of Delft University of Technology. The laboratory contained many mineral processing equipment viz., jig, table etc. of very high capacity. Photo 6 shows the experimental set up besides an industrial jig.

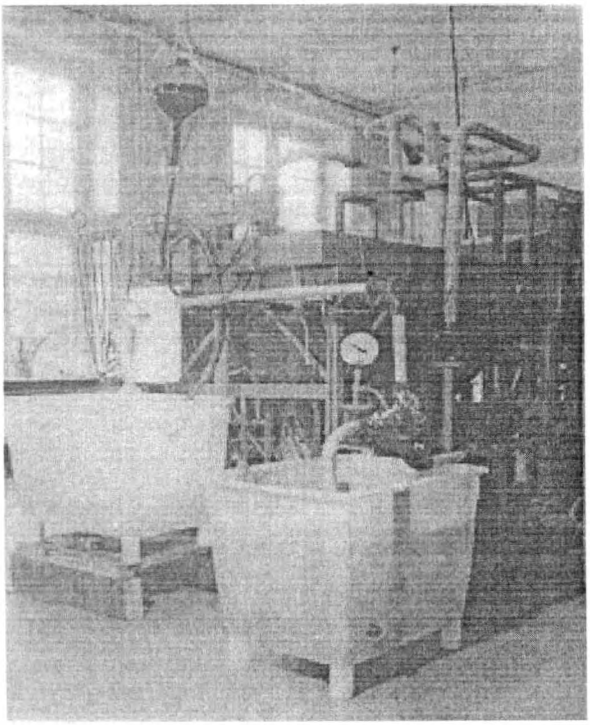


Photo 6: Experimental set up for flow visualization studies at Delft University

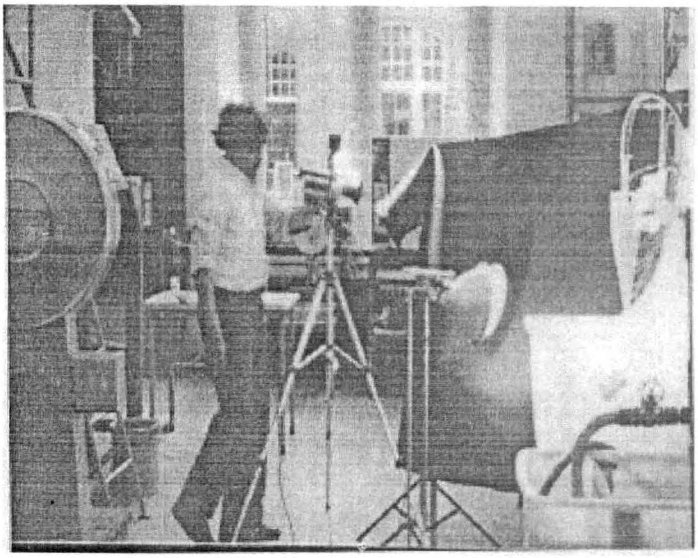


Photo 7: Photographic observation of flow field inside hydrocyclone at Delft University

In Southampton, Dr. Bhattacharyya worked on light phase hydrocyclone, having twin inlets, developed by Mechanical Engineering Department of Southampton University for oil-water separation, as visiting fellow of Science & Engineering Research Council, UK. Flow visualization experiments (Photo 8) carried out by Dr. Bhattacharyya and LDA measurements done earlier by the researchers of the Mechanical Engineering Department helped to develop the final design of Southampton University light phase hydrocyclones—which were later marketed by Sarck Baker as oilspin (Photo 9) and were used on north-sea platform (Photo 10) for oil water separation.

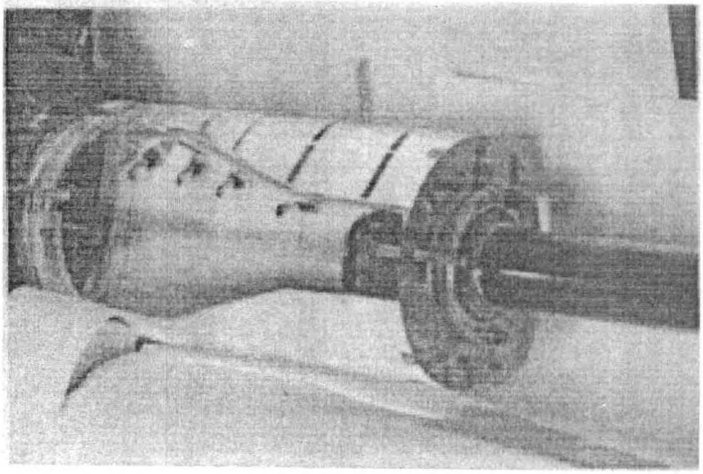
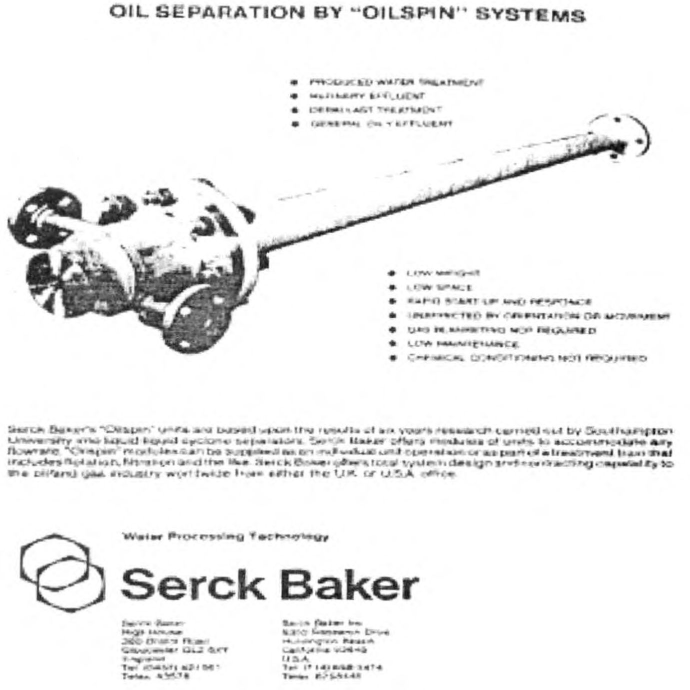


Photo 8. Experimental studies with Southampton Univ. light phase hydrocyclone


OIL SEPARATION BY "OILSPIN" SYSTEMS

- PRODUCED WATER TREATMENT
- REFINERY EFFLUENT
- DEBALLAST TREATMENT
- GENERAL OILY EFFLUENT

- LOW WEIGHT
- LOW SPACE
- RAPID START UP AND RESPONSE
- UNAFFECTED BY ORIENTATION OR MOVEMENT
- GAS BLANKETING NOT REQUIRED
- LOW MAINTENANCE
- CHEMICAL CONDITIONING NOT REQUIRED

Serck Baker's "Oilspin" units are based upon the results of six years research carried out by Southampton University into liquid liquid cyclone separators. Serck Baker offers modules of units to accommodate any flowrate. "Oilspin" modules can be supplied as an individual unit operation or as part of a treatment train that includes flotation, filtration and the like. Serck Baker offers total system design and contracting capability to the oil and gas industry worldwide from either the U.K. or U.S.A. office.

Water Processing Technology

Serck Baker

Photo 9: Oilspin marketed by Serck Baker

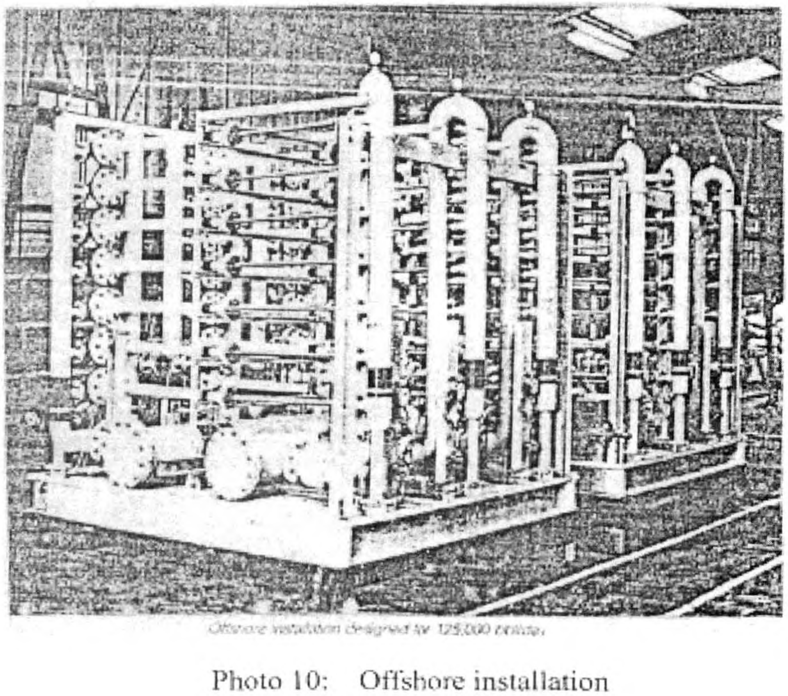

Offshore installation designed for 125,000 bbl/day

Photo 10: Offshore installation

Returning from UK, Dr. Bhattacharyya, a co-author, joined Central Mining Research Station (CMRS presently CIRMF), Dhanbad—as advised by the Director General, CSIR. At CMRS, Dr. Bhattacharyya created, right from scratch, central computer facilities for R&D and other activities of the laboratory and developed some software for land subsidence and general project management. But as no mineral processing activities, for making use of expertise on hydrocyclones, were carried out in CMRI, Dr. Bhattacharyya later joined National Metallurgical Laboratory (NML), Jamshedpur and finally got himself engaged in the Mineral Processing Division of NML.

Experimental studies that started from hydrodynamic laboratory of Calcutta University and continued to Delft University and Southampton University had helped Dr. Bhattacharyya in developing some fascination and expertise in experimentation. At NML, Dr. Bhattacharyya used to perform experiments, in different projects, be it In-house, Sponsored, Consultancy, Collaborative or CSIR Network project, either as team member or as project leader / coordinator, using many conventional / modern equipment like different gravity, magnetic, electrostatic separators etc. as well as hydrocyclones for waste utilisation and processing of ores and minerals viz., iron ore, coal, beach sand, barite, tungsten, phosphatic soil etc. of national and international origin at the level of bench and pilot plant scale (photos. 11-15).

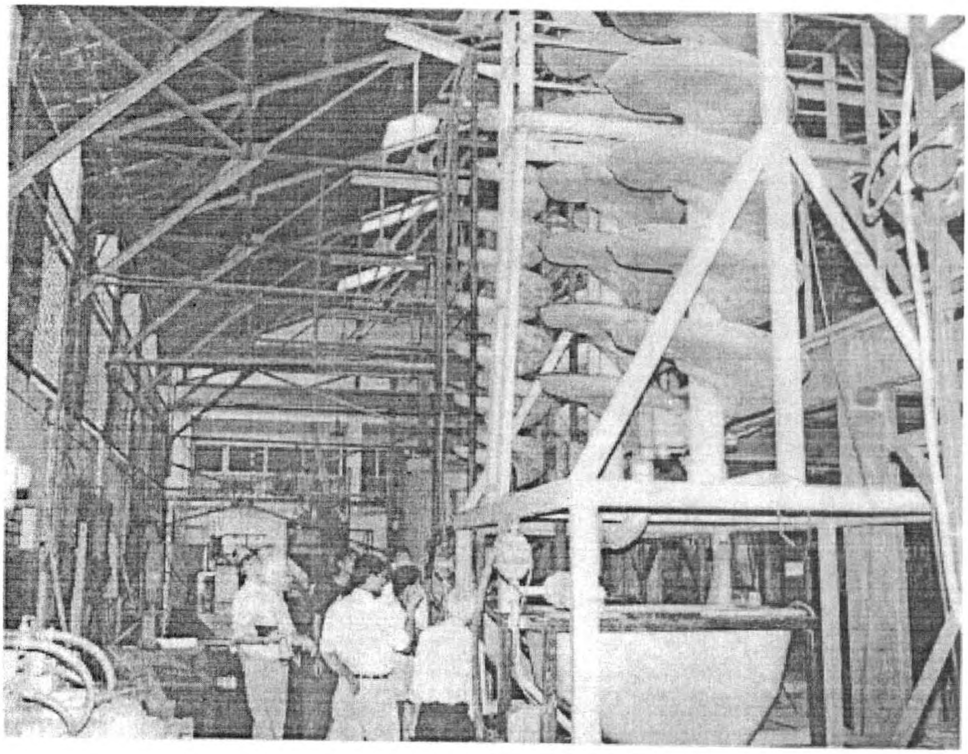


Photo 11: Studies with spirals for pre-concentration of beach sand at NML pilot plant

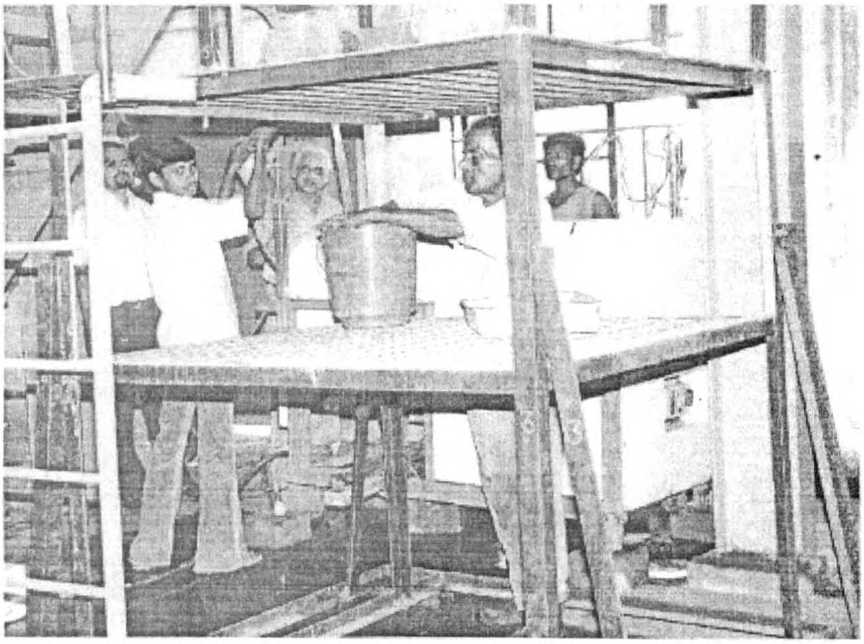


Photo 12: Treatment of coal fines using Multi Gravity Separator

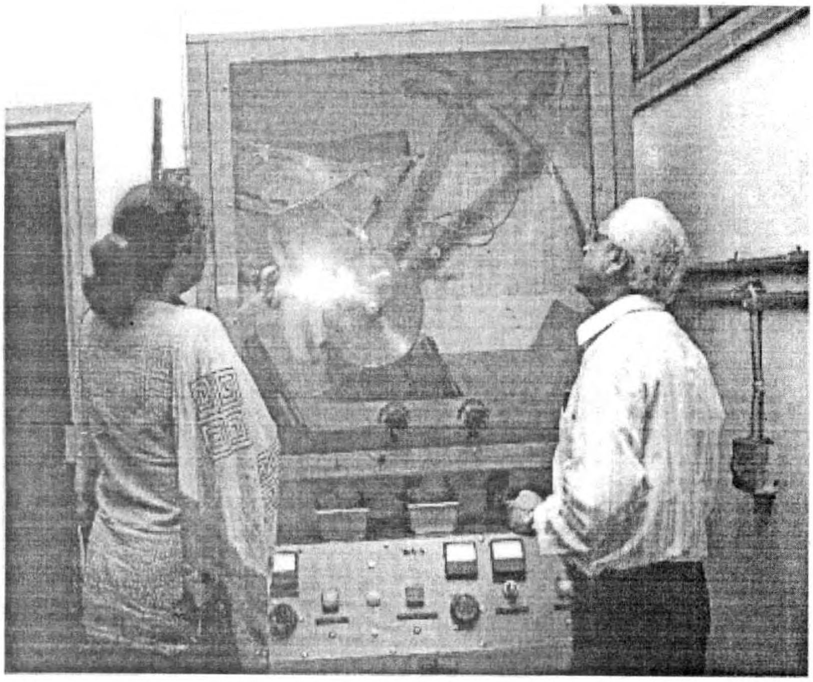


Photo 13: Separation of Ilmanite using high tension separator

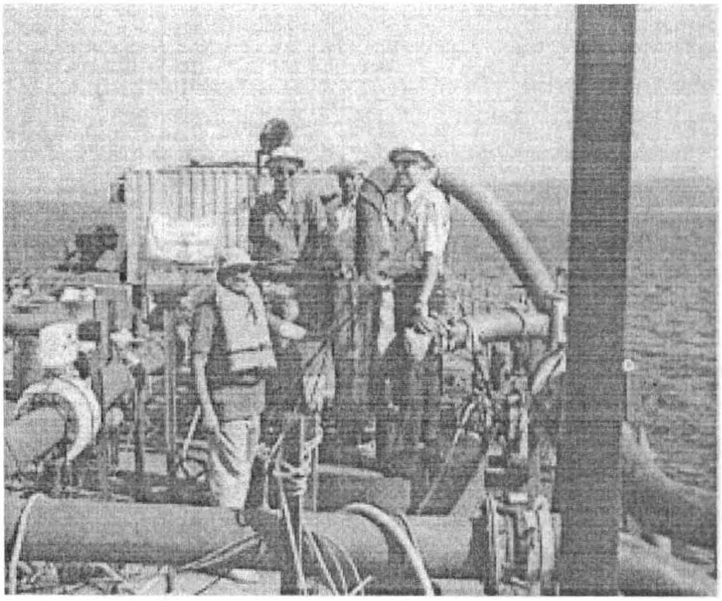


Photo 14: Off-shore mining & sample collection of CSIR network project on beach placer involving CMRI, Dhanbad, CMERI,-Durgapur & NML, Jamshedpur.

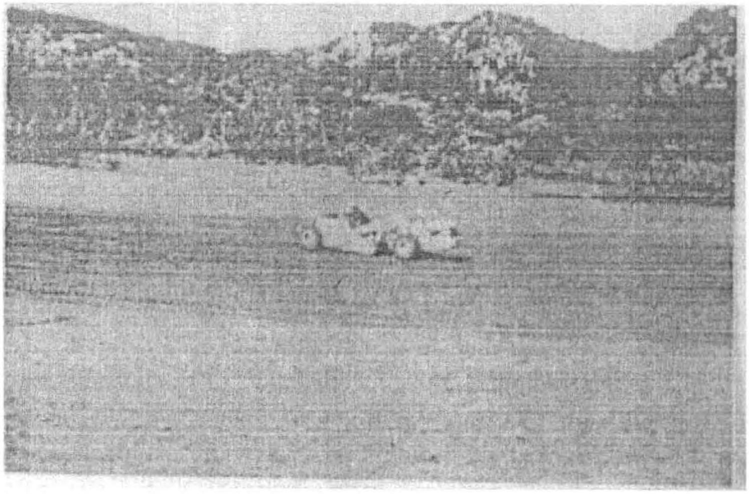


Photo 15: Phosphetic soil of Sukulu, Uganda (Collaborative project for production of fertiliser involving Rajasthan State Mines & Minerals Limited and Gujarat State Fertiliser Corporation with National Metallurgical Laboratory. Hydrocyclone, new design, were extensively used in this project while developing final flowsheet. Results were presented by Bhattacharyya in the International Mineral Processing Congress held at Cape Town, South Africa in 2003) and subsequently published in its Proceedings).

It is worth mentioning here that the facilities created by Prof. N R Sen had already helped many researchers to shape their career in the right direction and expected to do so in the years to come. As far as Numerical laboratory is concerned, it has been upgraded steadily at different stages to cope up with the need of students and research scholars for higher studies and academia for advance research. Presently, Applied Mathematics department has more than 100 computers in numerical laboratories (Photo 16) for students and research scholars besides all faculty member having computers at their desks to make use of the facilities to the fullest extent using computer networking system and licensed software like Matlab, Maple and Sigma plot with high quality Server.

Photo 16: Present Numerical Laboratory of Applied Mathematics Department

On the other hand, hydrodynamic laboratory, though started with and continued for first two/three decades or so in the similar line with lot of promise, unfortunately lost its way due to lack of interest, involvement and insight. During its prime time few students, research scholars and researchers of other institute were immensely benefitted by their studies and work in this laboratory. Even flume studies at the hydrodynamic laboratory helped student of Applied Mathematics department to secure employment at River Research Institute during seventies.

Revival of some experimental facilities of the hydrodynamic laboratory may again grow interest and invite involvement in experimentation for better understanding of the fundamentals of fluid dynamics in particular and Applied Mathematics in general and make it more attractive to the students. Further, addition of new experimental set up by research team guided by experienced faculty member/scientist/technocrats may remind and re-enter to the past exciting and useful chapter of the hydrodynamic laboratory of the Applied Mathematics department of Calcutta University and thus enhancing possibilities of producing more scientists/researchers to work in national/international laboratories to utilize their might to develop technologies which will be extremely useful for the advancement of science and in turn, industries as contribution of the Applied Mathematics Department.

Acknowledgement:—Authors are thankful to all who in any way helped in collection of information, be it from internet or from library or providing literature during preparation of this write up for 100 years of Applied Mathematics Department of Calcutta University. Photos are collected from different reports viz., Centre of Advanced Study in Applied Mathematics, Delft University of Technology, Southampton University & National Metallurgical Laboratory as well as Ph.D. thesis of Applied Mathematics Department, Calcutta University.

S.N. BOSE INSTITUTE

Uma Basu
Professor, Department of Applied Mathematics, University of Calcutta
e.mail : umabasu49@gmail.com

The Centre of Aclvanced Study in Applied Mathematics (CASAMCU organised The National Conference to celebrate the 50th Anniversary of Bose Statistics and 80th Birthday Anniversary of National Professor S.N. Bose in 1974. This conference was organised at the national level through a National Committee formed by Department of Science and Technology, Government of India. Immediately after that S.N. Bose Institute of Physical Science was established within the Calcutta University with the sole effort of Prof. M. Datta, Professor, Department of Applied Mathematics, with the cooperation of University authorities. After that many renowned physicists and mathematicians of the Calcutta University and Saha Institute of Nuclear Physics took interest in the academic program of the Institute. This Institute offered a M. Phil Course in Physical Science to the students who had Post-Graduate degree in Physics, Mathematics and Chemistry. The course curriculum includes advanced courses in Theoretical Physics, Pure Mathematics and Applied Mathematics and Physical Chemistry. Faculty members of the Calcutta University, neighbouring research Institutes like Saha Institute of Nuclear Physics taught this course to the students as a honorary Professor of the Institute appointed by the Calcutta University. This course was continued upto 1984, till the retirement of Prof. M. Datta. Many students and teachers pursued their research in the Institute and received Ph.D. degree from the University of Calcutta. As a burning candle enkindle other candles, from CASACU, SNBIPS, and from the latter, SNBNC for Basic Sciences were enkindled.

MA/MSc. SYLLABUS IN APPLIED MATHEMATICS— POST INDEPENDENCE PERIOD: SOME EVOLUTIONARY FEATURES

Arabinda Roy

Formerly, Professor, Department of Applied Mathematics, University of Calcutta

e.mail : roy_arabinda1@yahoo.co.in

Up to 1970 all Applied Math students were required to appear after two years for examination in eight papers of total 800 marks. General Mechanics (including particle dynamics, rigid dynamics, statics, basic concept of Lagrangian principle)was the main emphasis in the course with 200 marks. Syllabus of hydromechanics (100 marks)covered only nonoviscous fluid. Real analysis, complex analysis and linear differential equations were in third paper. Electricity and Magnetism (alternative choice being spherical astronomy) and Numerical Analysis (with a small course in statistical hypothesis) was each offered as a half paper (50 marks). Potential theory was a separate half paper. Numerical practical (50) marks was compulsory In the last year two full papers on special topics were offered. The choice of the special paper was mainly one of the three (a) elasticity (b) fluid dynamics (c) geophysics and geodesy. However in some years advanced electrodymics or compressible fluids or relativity was offered as special papers. While the main emphasis was on mechanics the students were encouraged to solve problems independently and had to work out new sums in examinations. There were some good teachers whose methods of teaching were unique. The reputation of some brilliant outstanding teachers like Professor Nikhil Ranjan Sen, Professor Nripendranath Sen, Professor Brati Shankar Ray, Professor Suddhodhan Ghosh, Professor Subodh Chakraborty and few others soon spread over whole India. The department was unique and the talking point among students and academics in India.

However, Numerical practical which was started by Professor Nikhil Ranjan Sen in the nineteen fifteees was very rudimentary. The student could only use hand facit machine and the logarithmic table for practicals due to lack of infrastructure.

Around 1970 a computer was installed for the first time in Radio Physics department of the university. The then Head of this department, Professor S.K. Chakrabarty took the initiative to introduce Boolean Algebra and Fortran IV programming language for the first time in the university. The student was required to write program and run in the computer. Potential Theory was then dropped as a separate paper and accommodated in the first two papers of Mechanics with Statics course being pruned.

Professor Chakrabarty also introduced a project work on the special paper having 50 marks with viva-voce . Through this project work students were trained to enter in the field of research. The author remembers that one of the students in Geophysics was offered a post in the Geological Survey of India on the basis of the project. Special papers were then allotted 100 marks each.

Professor Chakrabarty also introduced a seminar class in the Department where the students were bound to solve difficult problems and encouraged to give talk on various topics suggested by Professor Chakrabarty. Such a rigorous training helped then the students of Applied Mathematics to develop their confidence on the subject, to become a good teacher and a good researcher.

In the mean time the Mathematics Honours course has been modified. The department under the initiative of Prof. Parimal Kanti Ghosh, head of the department,in 1975 introduced some new changes in the M.Sc. syllabus. The M.Sc. course was then divided in Part 1 and Part 2 consisting of five papers each.

Theory of viscous fluids was then included in the third paper. An elementary course on quantum mechanics was introduced in General Mechanics and basic elasticity was introduced in continuum mechanics.

Algebra was introduced as a separate course in the name of Applied Algebra. It was a unique syllabus proposed by Professor P.K. Ghosh. It involved Lie groups, Lie Algebra and group representation theory giving exposure to the students regarding connection between mechanics and group theory. Another importance of this Applied Algebra syllabus was its connection with computer science through graph theory and automata theory. Roots of the study of dynamical systems which is an emerging field of research of twenty first century was planted by Prof. Ghosh in the syllabus of Applied Mathematics in nineteen seventies.

Metric spaces was introduced in the real analysis paper. Partial Differential Equations was included in 4th paper. Operations Research was introduced .While Electricity and Magnetism was still a separate paper, new choices, in optional papers were offered a) Dynamical Meteorology b) Dynamical and Oceanography c) Magnetohydrodynamics and Plasma Physics d) Operations Research-II e) Statitical Mechanics. New special papers were introduced: a) Quanum Mechanics b) Plasma Dynamics c) Advanced Computer Sciences and Cybernetics d) Advanced Optimization and Operations Research. Later a) Optimal Control Theory b) Mathematical Economics c) Mathematical Ecology were also added in the list of optional papers .Functional Analysis became now a full fledged half paper.Transform theory and Generalised Functions were included in fourth paper. By 2001 there was further changes in the syllabus .The Marks in Mechanics was halved to accommodate new changes Continuum Mechanics was now one full paper.Finally the syllabus in Part-I is as follows

a) Genaral Mechanics I and II — 50+50
b) Continuum Mechanics I and II — 50+50
c) Real Analysis & Generalised Functions — 50
d) Complex analysis, Analytical Theory of Differential equations, Integral Transforms — 50
e) Ordinary and Partial Differential Equations — 50
f) Electricity and Magnetism — 50
g) Applied Algebra — 35
h) Computer Programming — 35
i) Elements in Optimization and Operations Research — 30

Part II syllabus consists of the following:

Fifth paper

a) Course in Functional Analytic method — 35
b) Probability Theory and Stochastic theory — 30
c) Computing Sciences — 35

Sixth paper

a) Numerical Anaysis and practical — 50+50
b) Special papers + project = 2 x 80 + 40

50 marks was for tutorial.

Subsequently at the behest of U.G.C the department introduced semester system from 2009, duration of each semester being six months starting from July each year.

There are 5 papers of each 50 and a total of 4 semesters. Special papers now covered in 3 modules of each 50 marks and a project of 50 marks. All the previous special papers with updated version have been accommodated. We mention some changes. One module contains Real Analysis and History of Mathematics. Nonlinear Dynamics and Manifold Theory is another module. Functional analysis & Operator Theory, Integral Equation & Wavelet Transforms form another module.

Some Remarks

Applied Mathematics seems to be losing its importance due to lack of its practical applicability. The above mentioned special papers were chosen to include the then need of the country. Optional papers were also quite current. For example in geophysics, seismology and geophysical prospecting had very good applications . However, the teaching was more theoretical without the students being exposed to modern technology and how the bookish knowledge is applied in G.S.I, or petroleum industry. Elasticity is another subject which is connected with mechanical and civil engineering. In fluid mechanics special paper, the students should have some experimental knowledge to interact with the engineers. With this motivation Professor Nikhil Ranjan Sen established a hydrodynamical laboratory in the department before his retirement in 1959. Plasma Dynamics special paper was started in this Department in the middle of nineteen nineties.The same special paper was also running at that time in our nearest neighbor Physics Department. We had a nice opportunity to collaborate with them. It could give experimental exposure to our students and the then young teachers by visiting and taking part of the experiment with the students and teachers of the Physics Department. This experimental exposure is extremely necessary for mathematicians to compete with the physics community. It is not a difficult task for a student or a young interested teacher if he gets training in his/her young age. The same is true for Astrophysics.

To work in the R&D in industries, it is necessary to handle real life problems. There is always a gap between the industrialists and the applied mathematicians.This gap can be reduced by repeatedly sitting with them ,understanding their problems and then formulating those problems in mathematical language.

Similar is the case with Meteorology where forecasting is regularly needed along air flight path and for agriculture. The suggestion should be to take the students to Engineering department or meteorology department or GSI at Calcutta or invite industry people to give special lectures.This exposure will improve quality of research in the department.

As for the semester course the modules seem to be capsule of information packed. It is very difficult to digest all information in a short time. The students are memorising and getting high marks. The students should be encouraged to write small computer program themselves and try simple problems themselves in their project.

With computers now available in the department, serious efforts should be directed to improve the computer skill of each and every student e.g. finite element or computational fluid problems.

In 1983-1984 the department was the first among all science departments to introduce the M.Phil courses .The course offered was for one year in which a project paper of having 100 marks with 100 marks reserved for viva on various subjects and the project. Besides this students are supposed to attend a course of four papers ,each allotted 50 marks and 100 marks are allotted for seminar by the student. Of the 4 papers two were compulsory. One was Computational Methods and the second was Mathematical Methods (Analytical). For the other two papers (50+50) as many as twelve choices were given including all the special papers that are generally offered in MSc. classes.

The syllabus of the M.Phil. was so structured that it was a preliminary research degree and the students was given training in research methodology so that the M.Phil students become interested to do research in future. The students were given the option of submitting the project in the second year or in the first year.The course continued for more than 20 years. Initially college and school teachers and fresh MSc passed students were interested to attend this M.Phil course. Unfortunately later there were few students who attended this course.In 2013, The University has recognized this M.Phil. course equivalent to the preliminary one year compulsory course for Ph.D. There were some shortcomings initially. There was no scholarship for studying this course. Full time college and school teachers were usually not given permission/leave to attend this course. As a result few students could attend this course. No extra payments or no new teachers were allotted for this course .These shortcomings were recently removed. By then, the department has stopped this course from 2009 onwards. The department should take the initiative to introduce the course again or give the permission to the teachers to attend the courses during the summer holidays spread over two or three years or at night so that there no clash with their duty. This course should be modified.

ACTIVITIES OF THE DEPARTMENT: A CONTEMPORARY PHASE

Susmita Sarkar
Professor & Head, Department of Applied Mathematics, University of Calcutta
e.mail : susmita62@yahoo.co.in

The Department of Applied Mathematics is passing through hundred years. This Department was initiated by Sir Asutosh Mookerjee with his noble objective of developing the post graduate departments as centres of learning. His objective was then honoured by the Applied Mathematics community and the Applied Mathematics Department of Calcutta University received national acclaim. In crossing hundred years the department faced many ups and downs , but kept the march of progress with teaching various current topics, doing research in diversive fields and organizing workshops, schools and seminars at both national and international levels.

The department had revived the Centre of Advanced Study in Applied Mathematics (CASAM) in 1988 after its withdrawal in 1974, and continued for ten years till 1998. From the platform of the Centre, three outstation Instructional Workshops were held in three different universities. The first Instructional workshop was held at Visva Bharati, Santiniketan in 1995, second workshop was held at North Bengal University in 1997 and the third one was held at Vidyasagar University, Midnapur in 1998.The UGC funded these outstation workshops in a broad perspective with the motivation of developing the applied mathematics in Bengal through the initiative of the Centre. In the visiting scientist program of CAS, in 1997, Professor Debabrata Basu of Indian Institute of Technology, Kharagpur delivered a course of lectures on Lie algebras and Lie groups, Professor A.S.Gupta of Indian Institute of Technolgy, Kharagpur delivered a course of lectures on shock waves and Prof. B.K. Lahiri, Kalyani University delivered course of lectures on Metric Spaces.

Unfortunately the Centre of Advanced Study in Applied Mathematics was discontinued again in 1998 but this time only very briefly. In 2001 the department was identified by the UGC as a Department of Special Assistance (DSA). Presently DSA Phase-III is running. In different phases of DSA, several academic activities have been organized including regular holding of national seminars/conferences/workshops in the prescribed thrust areas of the UGC, organizing visits by distinguished scientists from India and abroad and arranging invited lectures.

The twenty first century is important in the history of Calcutta University. In 2001 University of Calcutta was awarded the status of a 'five star university' by the National Assessment and Accreditation Council. On 8 December 2005, the University Grants Commission declared Calcutta University as a "University with Potential for Excellence"(UPE). Under this UPE scheme, the UGC funded some groups of collaborative research projects to the faculty members of various Departments. Applied Mathematics Department received two such projects in the Computational Group, one in the field of Mathematical Biology and the other in the field of Plasma Physics.

To train the personnel through the University system, the UGC implemented the Scheme of Innovative Programs "Teaching and Research in Interdisciplinary and Emerging Areas" in the Tenth Plan period to support the specialised courses at Undergraduate and Postgraduate levels including 2 year post graduate diploma after graduation and one year post graduate diploma after post graduation in Interdisciplinary and Emerging Areas and to accommodate brilliant ideas and innovative proposals to influence teaching, research, academic excellence, societal growth and relevant activities in various disciplines which meet educational, national and global priorities and to promote group/departmental research work in universities and colleges.

The department of Applied Mathematics carried out this directive of UGC, by organizing many interdisciplinary seminars, conferences and workshops in collaboration with Physics, Chemistry and Economics departments of Calcutta University and other reputed institutes.

The Department of Science and Technology, Govt. of India, New Delhi sponsored a series of three National Workshops on techniques in Applied Mathematics in the Department of Applied Mathematics during 2005-2007. The instructional presentations in these workshops have been published by Narosa Publishing House in two books entitled "Techniques in Applied Mathematics" and "Applied Mathematics". These articles focus and highlight a number of basic techniques of Applied Mathematics both Analytical and Numerical in Ordinary and Partial Differential Equations, Dynamical Systems, Wavelets, Integral Equations, Chaos and Fractals. Quantum Information, Complex System etc.

All resource persons were from various Institutions and Universities such as Tata Institute of Fundamental Research, Indian Statistical Institute, Indian Institute of Science (Bangalore), Karnataka University, Punjab University and Indian Institute of Technology (Gauhati, Kharagpur and Bombay).

To promote interdisciplinary research, the department organized a series of lectures on different interdisciplinary areas by eminent scientists from reputed institutes. The speakers included Prof. Indrani Bose (Bose Institute, Kolkata), Prof. Debshankar Ray (IACS, Kolkata), Prof. Partha Guha (S.N. Bose Centre of Basic Science (Kolkata), Dr. Shantanu Das (BARC, Mumbai), Prof. M.S. Janaki (SINP, Kolkata), Prof. N. Parhi (NIISER, Bhubaneswar), Prof. Aloknath Chakrabarti (IISc, Bangalore) and Prof. Abhijit Lahiri (Vidyasagar College, Kolkata) who delivered lectures as visiting fellows during 2012-13 under University with Potential for Excellence (UPE) scheme. Faculty members and research scholars from Physics and Chemistry Department of our University also attended and benefited from those lectures. Our Vice-Chancellor granted Rs. 63,000/-for this purpose from the UPE scheme. The Department utilized this grant successfully.

In November, 2012, Dr. Shantanu Das, Scientist-H, BARC, Mumbai, delivered sixteen lectures on Fractional Calculus. This was supported from the merged grant of UGC.

Apart from these activities Department also regularly organized National Seminars every year from university BI fund. Two National level workshops on Techniques in Applied Mathematics were organized during 2005-2007 funded by DST. Two workshops on Astrophysics were organized in collaboration with IUCAA, Pune during 2009 and 2012.

To create human resource and generate knowledge source for academia and industry in the area of differential equations for solving real life problems, DST launched a five year long program "National Program on Differential Equations: Theory, Computation and Applications" (NPDE-TCA). Under this program several undergraguate, post graduate and advanced level workshops are being organized throughout the country. An Advanced Level Workshop "Non-linear Differential Equations: Dynamics of Complex Systems" was held in our department during September 23-28, 2013 under this NPDE-TCA program of DST and DST-PURSE Program of Calcutta University. Speakers of this Advanced Level Workshop were internationally reputed scientists. This was the first workshop in West Bengal under the NPDE-TCA program.

Since 2010 the department celebrates the Teachers' day by organizing a one day seminar in memory of the teachers of this Department who have passed away. Teachers' Day (2010) was celebrated in memory of Prof. Parimal Kanti Ghosh, 2011 in memory of Prof. Prafulla Prasun Chatterjee, 2012 in memory of Prof. Mahadev Dutta and 2013 in memory of Prof. Arabinda Mukherjee.

The 125th birth anniversary of the legendary mathematician Srinivasa Ramanujan was celebrated jointly by Department of Applied Mathematics and Department of Pure Mathematics, University of Calcutta by organizing the national seminar "Mathematics and Mathematical Sciences"on December 27-28, 2012.This was the first joint seminar between these two sister Departments.

Recently an international conference was organized in this department during February 12-14, 2014 in collaboration with Saha Institute of Nuclear Physics, Kolkata and Indian Association for the Cultivation of Science, Kolkata to commemorate 150th birth anniversary of Sir Asutosh Mookerjee and contributions of S.N. Bose, M.N. Saha and N.R. Sen. Professor Ralph Abraham, University of California Santacruz delivered the Keynote address on "Emergent Periodicity in the Field of Chaos". Twenty one eminent scientists from all over the country and abroad including Professor J.V. Narlikar delivered a lecture in this program in different sessions dedicated to Sir Asutosh Mookerjee, S.N. Bose, M.N. Saha and N.R. Sen.This heritage program was started with the university theme song "*Subho karma pathe dharo nirvayo gaan*", written by Kabiguru Rabindranath Tagore. Mr. Chittatosh Mukherjee, retired Chief Justice of Bombay High Court inaugurated the program.

Applied Mathematics Department has also received recognition and financial support under COSIST and DST-FIST programs. From the support of these programs, the department has developed four Numerical laboratories: two for the students and two for research scholars. The department has purchased more than hundred computers, MATHEMATICA, MAPLE, MATLAB softwares which have improved computation based research of the faculty members of the Department. Under UGC-DSA program, Prof. Siddhhartha Sen of Trinity College, Dublin and Prof. Jayanta Kumar Bhattacharjee of S.N. Bose National Centre of Basic Sciences, Kolkata and Prof. Utpal Banerjee of University of California, Irvine respectively taught courses in Manifold Theory, Nonlinear Dynamics and Linear Algebra in the M.Sc. course of our department during their stay as a Visiting Professor in the department. It bears a mention that a treatise on Manifold theory by Prof. Siddhartha Sen based on his course of lectures in the department was published by the University of Calcutta in 2011. Eminent scientists like Prof. Andreas Fring (City University, London), Prof. Guenther van Gehlen (University of Bonn, Germany), Prof. Peter Leach (University of Kawazulu, Natal, Durban) visited our department.

Presently Applied Mathematics Department has a collection of fourteen thousand books in its departmental library. Every year the department purchases new books of rupees more than ten lakhs received from university, Government of West Bengal, National Board of Higher Mathematics and other funding agencies. Department also has a rich collection of Russian and German books and journals of Mathematics purchased at the time of Professor Parimal Kanti Ghosh.

Our department has produced generations of quality students. It is a matter of pride to mention that in last twenty years some of our students are in the faculty of different prestigious institutions like Harish Chandra Research Institute, Allahabad; Indian Institute of Technology at Kanpur; Roorkee, BHU and Rajasthan; Indian Institute of Mathematical Sciences, Chennai, CSIR-National Chemical Laboratory, Pune and Indian Statistical Institute, Kolkata.

In last twenty years teachers of this department enjoyed different prestigious Associateships of ICTP (International Centre for Theoretical Physics, Trieste, Italy), TWAS (Third World Academy of Sciences), IUCAA (Inter University Centre for Astronomy and Astrophysics) and Indian Institute of Mathematical Sciences, Chennai apart from receiving UGC career award and Fellowship of National Academy of Sciences.

We are bearing a glorious heritage over hundred years. Our responsibility is to maintain this heritage by maintaining the quality of teaching and research. This needs strong academic motivation and deep respect for the Alma Mater. Once this Department reached at the highest academic level because of the pioneering academic leaderships. Professor N.R. Sen and Professor S.K. Chakraborty, with their commanding personality, enthused the young teachers to build them up not only for their own upliftment but for the upliftment of the department. They showed light to their followers.

EPILOGUE

Dilip Kumar Sinha
Formerly, Sir Rashbehary Ghose Professor of Applied Mathematics University of Calcutta
email : dilipkumarsinha@rediffmail.com

In the earlier pages, an overriding consideration has been to focus on some leading heights to which the Department of Applied Mathematics, University of Calcutta could elevate itself through the last one hundred years of its existence. A chronological description of the events in the department can hardly be in commensurate with the image that the department has acquired through the decades, despite impediments and irritants.

The label 'Mixed' for the department served the purpose in its initial days and paved the way, for adaptation of the label 'Applied' which has, doubtless, come to a stay. That has, indeed, been a process, far from being mundane. On the contrary, the approach required a lens that has allowed a distinctive perspective for the department to flourish, without losing its intrinsicality. Any delineation of the activities of the department cannot be reducible in terms of vocabularies and outfits that may fit in an usual glossary. The word 'applied' has endowed the department with a capability so as to reach out to ideas that are amenable to conceptualization with elegance. The department can thus be proud of having a mathematical habitat characterized by diversity, plurality and inclusivity drawn from fields of human activity. Apparently, some steps might not have gone wholehog; for example, the Hydrodynamical Laboratory of the Department, as emvisaged by Professor N.R. Sen.

A *forté* over the decades has been the Centre of Advanced Study in Applied Mathematics, Calcutta University (CASAMCU) which suffered from disturbances because of insidious pretexts elsewhere. The resilience of the department, in the wake of such disabling attempts, is well reflected by its proliferating programmes, through a wide diversity of seminars, symposia, workshops etc. Didn't the 'Research Working Party on Nonlinear Evolving Systems' set in consolidation and augmentation of engagements, under the auspices of CASAMCU?. In other words, the department has kept on rejuvenating its academic tenor on a continuing basis, as referred to in the earlier presentations. Several mathematically innovative sequels have kept on emerging.Nonlinear forays must have accrued excellent dividends in the areas of plasma and other studies. At the same time pursuits, both in teaching and research on mathematical biology and mathematical ecology cannot but reckon with studies on 'dynamical systems'. The department has not minced efforts to seek the basics of any frontier theme to the extent they fulfil the innate mettle of applied mathematics.

As may be recalled, the department in its initial days, had the trio Bose-Saha-Mahalanabis engaging themselves in providing an exposure of Albert Einstein's fundamental paper on 'Relativity'. Undoubtedly, they could do so because of the unsullied inspiration from Sir Asutosh Mookerjee, the Vice Chancellor of the University of Calcutta, who, as history tells us, had to refer to the year 1905 (in the context of Special Theory of Relativity) for justifying the appointments of budding young scientists like Saha and Bose. That has been put up as the initial period of what is often described in circles of historians, as 'externalized history'. Such phases got fuelled after Bose and Saha's return to Calcutta University i.e. after their sojourns at Dacca and Allahabad. Professor Bose's becoming a National Professor, also after his stint as Upacharya (Vice Chancellor) of Visva Bharati, afforded them to carve out a distinctive niche in realms of theoretical physics. It is to be noted that Professor N.R Sen resumed his academic kinship with Professor Bose in the premises of Indian Association for the Cultivation of Science —an heritage institution which had the famous Ripon Lecture by Professor N.R. Sen on 'Turbulence'. Professor S.K. Baneriee, a former Ghose Professor of Applied Mathematics also delivered the Ripon Lecture, on Seismology in Himalayan arena. As a part of history, one cannot be oblivious of Professor N.R. Sen's another classmate Professor M.N. Saha. Professor Sen was a Treasurer of Indian Science News Association (ISNA) and Professor M.N. Saha, its Secretary. ISNA came into being with Professor P.C. Ray as its President, just a couple of years before Professor Saha came back to Calcutta University. The purpose in dealing with this information is that all the three scientists—Bose, Saha and Sen–reared in ambiences of applied mathematics, could develop mindsets capable of reaching out to wider domains. As a matter of fact, Professor N.R. Sen's valuable essays on applied mathematics from a developmental standpoint published ISNA's journal 'Science & Culture' must have influenced trajectories of pursuits in the department over the decades.

As the foregoing pages must have revealed by now, the leadership for building up afresh, with widening ambits, was taken up by Professor Mahadev Dutta. Satyendranath Bose Institute of Physical Sciences shouldn't be taken as a run-of-the-mill enterprise. True to the culture and temper of applied mathematics, Professor Dutta took up the cudgels for dimensionalising study and research in physical sciences with an enormity of interdisciplinary traits. Professor Dutta could assemble around its aegis, academic functionaries of national and international distinctions. As N.R. Sen Professor in CASAMCU, Professor Dutta had to take up bold stands, seemingly anti-establishment, so that moorings of applied mathematics (and basic sciences, as well) could have a site in the portals of the University system. This shouldn't be taken to mean that the Fluid Dynamics, a mainstay of studies in the department, did not engage the attention of the department. The collaboration with Indian Society of Industrial and Applied Mathematics resulted in a three-day national symposium under the aegis of CASAMCU. One should necessarily recall the Birth Centennial Colloquium on 'Mathematical Contributions of Satyendra Nath Bose and Meghnad Saha: In Retrospect and Prospect' under the auspices of CASAMCU in 1993. In passing, one should refer to the 'Bose, Saha and Mahalanabis Birth Centenary Celebrations' on January 1, 1993, which the Department of Applied Mathematics of the University, was entrusted with, by the University of Calcutta.

Looking back, one should take pride in saying that the department of Applied Mathematics did not shy away from aligning itself with the unstinted move by the academic community of the University, for the installing the computer system in the premises of the University College of Science & Technology, despite the personalities present on the occasion being physically heckled and humiliated. True that the Department has numerical studies as a part of instruction since the early thirties but it was looking for new facilitations so as to arrive at the frontiers of the computational aspects in applied mathematical studies. In particular, Cybernetics, Automata Theory etc. could hardly become instructional foci of the department, if there be no computational facilities and exposures in the department on an ongoing basis.

In sum, one ought to say that the department of the Applied Mathematics, continues to be a bedrock for edifices on cardinality of challenging ideas and concepts. Several anecdotes, exemplars and happenings are strewn through its history and only snapshots are given. In the post-independence period, angsts, genuinely academic, may have crept in because of some allies having stolen a march over the leadership; for example, an institutional landscape elsewhere in the city itself and that too, with a relatively extraordinary support from the exchequers. Yet, the department has not abjured its collaborative and interactive genre of organizing academic programmes, as evinced by the International Conference on Emerging Trends in Applied Mathematics on February 12-14, 2014 dedicated to Sir Asutosh Mookerjee. Isn't it more than an endeavour for paying, a tribute to the iconic figure Sir Asutosh Mookerjee, along with three pillars on applied mathematics, namely, S.N. Bose, M.N. Saha and N.R. Sen ?

AFTERWORD

Here is a set of Appendices that bring out a resume of few personalities who shaped the image of the department in a variety of ways. Equally, it is a sacrilege in not being capable now to have portrayals of legendary figures like Nripendra Nath Sen, Sudhodhon Ghosh, Bibhuti Bhusan Sen, Kshetra Mohan Basu, Sisirendu Gupta, and select few from the erstwhile Presidency College, Kolkata.

Appendix I : Professor Ganesh Prasad and Dr. Bibhuti Bhusan Dutta

Appendix II : Professor Nikhil Ranjan Sen : A Centennial Homage

Appendix III : Professor Sudhangshu Kumar Banerji and Professor Subodh Kumar Chakrabarty : A Brief Resume

Appendix IV : Professor Parimal Kanti Ghosh : A Tribute

Appendix V : Professor Mahadev Dutta

Appendix VI : Some Distinguished Alumni : A Brief Write-Up

APPENDIX-I

Professor Ganesh Prasad

Prof. Ganesh Prasad born in Ballia, a small town in the United Provinces, India, on November 15, 1876, He was awarded the D.Sc. degree of the University of Allahabad at the age of twenty-two years, and then studied at Cambridge and Gottingen as a Government of India scholar. After serving for ten years as a Professor of mathematics in his native province on his return from Europe, in 1914 Sir Asutosh Mookerjee, the then Vice-Chancellor of Calcutta University, invited him to occupy the Rash Behari Ghosh Chair of Applied Mathematics and he joined. He was the first Rashbehari Ghosh Professor in the University of Calcutta. He left this post four years later to join the Benares Hindu University but came back to Calcutta in 1923. This time he became the Hardinge Professor of Higher mathematics, which post he occupied until the time of his death. Prasad's research was on spherical harmonics, potential theory, Bessels Functions etc.

During his stay at Cambridge, he studied with men like Hobson, Forsyth, Baker and Lamour. His paper entitled 'On the constitution of matter and the analytical theories of heat', was appreciated by Prof. Klein at Gottingen and was published in the Gottingen Abhandllingen. While at Gottingen, he came into contact with mathematicians like Sommerfeld, David Hilbert and Georg Cantor.

Dr. Prasad was elected President of the Calcutta Mathematical Society in 1924 and the vice-president of the Indian Association for the Advancement of Science, Calcutta and held both these offices till his death. He was a founder member and Fellow of the National Institute of Sciences, India (now Indian National Science Academy). He was also one of the founders of the Agra University.

Dr. Prasad published over fifty papers in various Indian and foreign research journals and wrote 11 books of which 'A Treatise on Spherical Harmonics and the Functions of Bessel and Lame' has become almost a classic work. He worked on a variety of subjects which included the Theory of Potential, Theory of Functions of a Real variable, Fourier series, Theory of Surfaces, etc. At the time of his death, he was engaged in writing a paper on the expansion of an arbitrary function with infinite zeros.

Professor Ganesh Prasad deserved credit for creating interest in history of Mathematics in India. He himself was a historian of mathematics and his two students A.N. Singh and B.B. Dutta became pioneers in the history of Hindu Mathematics.

Dr. Bibhuti Bhusan Dutta

Dr. Bibhuti Bhusan Dutta (1888-1958) passed M.Sc in Mixed Mathematics of Calcutta University in 1914 and was appointed lecturer in this department. Later, he was awarded prestigious Prem Chand Roy Chand scholarship and Elliot prize. He worked on Hydrodynamics and awarded D.Sc in 1920. One of his publications was "On the period of vibrations of a straight vortex pair" (1921), Proceedings of the Benaras Mathematical Society Vol 3, pg 13-24.

Dr. Dutta possessed a saint like nature with religious belief. He first declined Rashbehari Ghosh Professorship as he wanted to become a *sanyasi*. Later he accepted this and worked three years in this post but not accepted any additional allowance. He was a follower of Shankaracharya and was believed in Visuddha- advaita-veda.

Dr. Dutta was a pioneer in the history of Hindu Mathematics. His original works in this field were documented within the period 1925-1947. He delivered an address on "Contribution of the Ancient Hindus to Mathematics" to the Allahabad University Mathematical Association on December 20, 1927. This was published in Volumes I and II of the Association's bulletin (Vol 1, pg. 49-73; Vol 2, pg. 1-36. Part I reprinted, Vol 12, pg. 1-36). In 1929 he resigned from Calcutta University. But in 1931, by special invitation he delivered Readership lectures in Calcutta University on "The Science on the Sulba". In April 1932, he wrote a short review of "Siddhanta Sekhara of Sripati" which was edited by Babua Mishra and published by Calcutta University. He finally retired from Calcutta University in 1933. In 1938 he took *sanyasa* and became known as Swami Vidyaratna. In the same year Part-II of his History of Hindu Mathematics was published. The end of his life he spent at Puskara in Rajasthan where he died on 24h March, 1958 [R.C.Gupta, "Bibhuti Bhusan Dutta (1888-1958), Historian of Indian Mathematics,Historia Mathematics Vol 7, pg 126-133(1980)]

APPENDIX-II

Professor Nikhil Ranjan Sen : A Centennial Homage

Nikhil Ranjan Sen who held the chair of Sir Rashbehari Ghose Professor of the Department of Applied Mathematics, Calcutta University for thirty five years died on January, 13, 1963. An impressive personality as he was, Nikhil Ranjan's presence is felt even four decades after his death among his contributions in different areas of Applied Mathematics and among his students holding positions at different institutions.

Youngest son of Sri Kalimohan Sen and Srimati Bidhumukhi Sen, Nikhil Ranjan was born in the District of Dacca (in Bangladesh) on May, 23, 1894. Hewas educated at Dacca Collegiate School, Rajshahi School and Rajshahi College. At the Entrance Examination of the Calcutta University in 1909 he secured a first grade scholarship. At the I.Sc. examination he stood third in order of merit, the first and second positions having gone to the renowned Physicists Prof. Satyendra Nath Bose and Prof. Meghnad Saha respectively. During his stay at Rajshahi he was greatly influenced by his uncle who was himself a mathematician. He studied Mathematics (Hons) in the Presidency College, Calcutta and M.Sc. in Applied Mathematics (then called Mixed Mathematics) at the Calcutta University. Two of his classmates were the eminent Physicists Prof. Satyendra Nath Bose and Prof. Meghnad Saha. The College had at that time a galaxy of eminent teachers like Sir J.C. Bose, Sir P.C. Ray, Prof. C.E. Cullis and Prof. D.N. Mullick. Their deep commitment to the pursuit of knowledge and selfless devotion to the national cause were sourcesof inspiration for these budding scientists. At the B.Sc. Examination Nikhil Ranjan stood third in the first class, the first two positions going to Satyendranath and Meghnad respectively. Nikhil Ranjan took his M.Sc. degree in 1916 in Applied Mathematics and secured the first position.

After his post graduate degree Nikhil Ranjan chose a research career and devoted himself to advanced studies in different branches of Applied Mathematics and Theoretical Physics. The Department of Applied Mathematics was then in its infancy. Sir Asutosh Mookerjee, the then Vice-Chancellor of the Calcutta Universtty and its main architect as a seat of learning, soon recognised the potentiality of Nikhil Ranjan and appointed him as a teacher in the said Department in 1917. At that time Nikhil Ranjan's main interest was in the theory of Newtonian Potential and the mathematical theories of Elasticity and Hydrodynamic waves. He published a number of papers and was awarded D Sc. degree of the Calcutta University in 1921. Immediately thereafter he proceeded to Europe on study leave from the University and worked at different centres of advanced study and research in Berlin, Munich and Paris. He worked on General Theory of Relativity and Cosmology under Prof. Max Von Laue and was awarded the Ph.D. degree of the Berlin University During his stay at Germany he came in contact with Max Planck, Albert Einstein, Arnold Sommerfield and Louis de Broglie and was induced to study of Quantum Physics. He studied the Mathematical theory of Probability under Prof. Von Miser and Topology under Prof. Schmidt. This exposure to different branches of Mathematics and Theoreical Physics widened his horizon and enabled him to take up research in various branches of Applied Mathematics.

On his return to India, Nikhil Ranjan was appointed Rashbehari Ghose Professor of Applied Mathematics, Calcutta University in 1924. He soon devoted himself to building up the department and introduced the study and research in diverse branches of Mathematics & Theoretical Physics. This practically marked the beginning of a systematic study and research in Applied Mathematics throughout the country. Under his able leadership the Department of Applied Mathematics, Calcutta University drew national acclaim as one of the most important centres of learning for research in various disciplines of mathematical studies such as the Theory of Relativity, Astrophysics, Quantum

Mechanics, Statistical Mechanics MHD, Fluid dynamics, Elasticity and Ballistics flourished under his guidance. He initiated research in Plasma Physics He started a small laboratory of numerical computation for his M.Sc. students. For some years before retirement he was engaged in setting up a small hydrodynamical laboratory with a flume and a wind tunnel.

To recall his outstanding contributions his investigations on the models of the Universe, his study of the problem of internal constitution of stars and construction of stellar models based on thermonuclear energy generation laws, his works on wave mechanics, including Dirac's relativistic equation, are some of his numerous works. In fluid dynamics he led a team of workers investigating problems of boundary layer, isotropic turbulence and shock waves.

Professor. Sen was associated with numerous scientific societies and institutions in the country. He was the fountainhead of the Calcutta Mathematical Society. He was a founder member of the Indian Astronomical Society Ha was one of the founding fellows of the National Institute of Science in India founded in 1935. In 1936, he was elected President of the Mathematics Section of the Indian Science Congress Association.

A many-splendoured personality as he was, he not only carried out research himself but built up a strong band of research workers around him. He took keen interest in the problems of teaching mathematics at the school level and gave unstinted support to his friend Prof. S.N. Bose when Prof. Bose established the "Bangiya Bijnan Parishad".

After retirement from Calcutta University he was Honorary Research 'Professor of the Indian Association for the Cultivation of Science, Calcutta when death overtook him.

History will remember him not just as a great savant of Mathematics but as one of the great luminaries of the galaxy that brought about the Indian renaissance of science. A fitting centennial tribute to him would be to carry on the tasks he initiated for the promotion and propagation of Applied Mathematics.

N.R. Sen Birth Centenary
Celebrations Committee
Department of Applied Mathematics
Calcutta University

APPENDIX-III

Professor Sudhangshu Kumar Banerji and Professor Subodh Kumar Chakrabarty : A Brief Resume

The Department of Applied Mathematics, University of Calcutta has a long tradition of research in Mathematical Geophysics. As early as in 1918-19, **Prof. Sudhangshu Kumar Banerji**, the second Rashbehary Ghosh Professor of the Department had published a paper on surface waves [Bull. Cal Math Soc, 10(1-4), 1918-19, 1-10]. He had done a considerable amount of original research on Elasto-dynamics and Mathematical Geophysics. The most notable publications of Prof S.K. Banerji in Mathematical Geophysics are

1. Diffraction phenomena in the testing of optical surfaces, Nature, Vol 10, 1917
2. The depth of Eartquake's focus, Nature, Vol 109, pg. 108, 1922
3. Seismograms and their significance [Bull. Cal Math Soc, 11, 1919-20, 239-254] and
4. Spherical waves of finite amplitude produced by the sudden explosion of a detonating gas contained within a spherical envelope [Bull. Cal Math Soc, 12(1-4), 1921]

Prof S. K. Banerji also earned the distinction of becoming the first Indian Director General of the India Meteorological Department (IMD) in 1944. It is well-known that right from its inception, IMD was involved in geophysical studies and prediction. Prof S.K. Banerji with his knowledge of Applied Mathematics and Geophysics gave committed leadership to the establishment.

Another brilliant product of the Department of Applied Mathematics, **Prof. Subodh Kumar Chakrabarty** joined the department as a member of the faculty in 1935. In the initial years, he worked mainly on Cosmic Showers. But in 1945, he left Calcutta and became the Director of Colaba and Alibag observatories in Bombay and worked there till 1948. In 1948, Dr. Chakrabarty joined the California Institute of Technology, Pasadena, U.S.A. as a Visiting Research Fellow. He worked mainly on Applied Geophysics and concentrated on geophysical prospecting for oil and minerals and calibration of electromagnetic seismographs. In California, he came in contact with world famous geophysicists such as Prof B. Gutenberg, Prof C.F. Richter and Dr. Benioff After returning to Calcutta, he worked as a Professor and Head of the Department of Mathematics in B.E. College, Sibpur, Howrah from 1949 to 1963. During this period, with financial support from CSIR, he established a seismographic station at B.E. College and also maintained a small observatory in the sea beach of Digha in Midnapur. He and his group of co-workers conducted study of microseisms and sea waves and their correlation with cyclonic disturbances. In 1963, Prof Chakrabarty joined the Department of Applied Mathematics, Calcutta University as the Rashbehary Ghosh Professor and took over the reins of the Department. In the long research career of Prof Chakrabarty, he and his co-workers developed in details methods for estimating precisely the instrumental constants of the electromagnetic seismographs, the methods of their calibration and also variation of their "magnification" with changes in "damping" and "reaction". These results and graphs can be used for precise estimation of the instrumental constants without disturbing their operating conditions.

A summary of some of these works was incorporated in the UNESCO publication entitled "Manual of Seismological Observatory Practice" prepared by the International Committee for the Standardization of Seismographs and Seismograms. The committee was formed following the resolution of UNESCO. Prof S.K. Chakrabarty represented India in this committee and attended its first meeting in Paris in 1963. After detailed discussions, Prof. Chakrabarty of India, Prof. Grenet of France and Prof J.T. Wilson of U.S.A. were entrusted with the responsibility of drawing up the section on "Instruments and Their Choice, Adjustments and Calibration". In 1967, their report was published by UNESCO as a reference manual and was made available to different seismological observatories of the world.

APPENDIX-IV

Professor Parimal Kanti Ghosh : A Tribute

Professor Parimal Kanti Ghosh belonged to the generation of teachers coming out shiningly following the great galaxy of elderly teachers. Way back, in 1957-58, he used to teach a fifty-mark course on Electricity & Magnetism and also Numerical Analysis, both theoretical and practical. Professor Ghosh had something distinguishably remarkable from the elderly generation, although he had strong emotional and academic too, kinships with Professor N.R. Sen and Professor S.N. Bose. Professor Ghosh must have absorbed the qualities of versatility and perhaps often going well beyond, the elderly generation. He developed links with the Department of Applied Mathematics initially as a researcher and a part-timer belonging to Bangabasi College, Kolkata. He was a brilliant student topping the lists at the undergraduate and postgraduate levels. Professor Sitesh Chandra Kar, whom we got used to find him browsing through mathematical journals of Calcutta Mathematical Society, had stints in the same department, being a wholetimer of Bangabasi College. Professor Kar, to my perception, stands as an exemplar who was associated with the department for providing a global dimension to pursuits in mathematics. Professor Ghosh could carry on ably this legacy of the department. Having interacted with him later, I did find in him a forward-looking mathematician who seldom made any fetish of acquiring mathematics, pure or applied. It often required to the people of mathematical community that, old or young, to rush to Professor Ghosh in case the acquirer found himself in difficulties about the status of a topic or a branch of mathematics. Professor Ghosh never minced any generosity on such scores, when he was approached by any person to whichever apparent alignment he or she might have been situated.

Professor Ghosh was heavily inclined and that also on an ongoing basis, towards curriculum renewals and development. He used to yearn for a curriculum reflecting latest developments on concepts and ideas. He was the frantically enterprising for inclusion of courses in discrete mathematics, interdisciplinary areas like mathematical biology, cybernetics, automata theory, computability etc. He didn't at all abjure the classical pursuits but those too, with modern shapes. He believed in, as I could understand him, filtering down frontiers of mathematical knowledge for the higher levels down to the school levels. I have had highly agile and fruitful interactions with him in such directions. I still have few books, in Russian, given to me, particularly on geometry, because of my attachment with the works of the erstwhile Soviet mathematicians on Transformation Geometry.

Professor Ghosh, like his teachers and mentors, hardly confined himself to mathematics only. His association with Professor S.N. Bose must have enabled him to flourish in the entire arena of science with grace and finesse

Professor Ghosh stands, in my memory, as one clad with a full shirt, a dhoti and a pair of simple shoes, but immensely possessive of a global mindset of learning and acquisition, which he did evince after being formally retired as Sir Rashbehary Ghose Professor of Applied Mathematics, University of Calcutta.

Dilip Kumar Sinha

APPENDIX-V

Professor Mahadev Dutta

Professor Mahadev Dutta started research in Statistical Mechanics under guidance of inspiring teachers Dr. S.C. Kar and Professor N.R. Sen, the then Head of the Department of Applied Mathematics. Professor Dutta proposed a new statistical theory of real gases where thermodynamic probability is calculated in a new way. In 1951 he was awarded prestigious research fellowship from National Institute of Sciences of India and Imperial Chemical Industry to pursue further research in Statistical Physics under supervision of Prof. S.N. Bose. His research contribution leads to a new theory, the so-called Dutta-Bagchi Theory of Strong Electrolytes in solution. He was one of the successful teachers in the North Bengal University, Jadavpur University and IIT Bombay. He visited the Universities in Europe, earlier Soviet Union and USA. He delivered Tallman Foundation Lectures in Bowdian College in the United States in 1967. He also delivered Rajsekhar Bose Memorial Lecture in Bangiya Bijnan Parisad

Professor Dutta had received many academic honours for his outstanding academic pursuits. He was a member of the American Mathematical Society, Mathematical Association of America, and Society of the Applied and Industrial Mathematics, Indian Association for Cultivation of Science, Indian Science Congress Association, Indian Science News Association, and Bangiya Bijnan Parisad. He was a founder President of Forum of Interdisciplinary Mathematics.

Professor Dutta was a life-member of Calcutta Mathematical Society, established by Sir Asutosh Mookerjee. His outstanding service as a Council Member, Secretary of the Society from 1972 to 1983 is truly phenomenal. He was the President of Calcutta Mathematical Society during 1984-86. No doubt that this unique leadership as Secretary and President, major programs of the Calcutta Mathematical Society achieved their greatest success.

Professor Dutta is one of the most distinguished pure and applied mathematicians in India and in the world. He is also well known for his dedicated and outstanding services through excellence in research, teaching and able leadership of Indian Institutes of Higher learning and of scientific organizations at national and international levels. He made significant contributions to a wide variety of subjects including Statistical Theories of Real Gases, Theory of Strong Electrolytes in Solution, An Essentially Statistical Approach to Thermodynamic Systems, Partitions of Numbers, Integral Transforms and their applications to Ordinary and Partial Differential Equations, Special Functions, Theory of Elliptic and Associated functions, Statistical Mechanics, Continuum Mechanics, Information Technology, Topology and Relativity. As a researcher, he is one of the most effective sources of inspiration for his fellow—faculty members, students at doctoral and post-doctoral levels.

Uma Basu

APPENDIX-VI

Some Distinguished Alumni : A Brief Write Up

Professor Anadi Sankar Gupta

Professor Anadi Sankar Gupta (M.Sc, 1952-54) was a renowned applied mathematician. His doctoral thesis was done under the supervision of Prof G. Bandyopadhyay at the Indian Institute of Technology Kharagpur in 1958. He further acquired a D.Sc. from the same Institute in 1966.

He joined the faculty of IIT Kharagpur in 1957 as an associate lecturer and served there till his retirement in 1993. Till his death, he was an INSA Senior Scientist and emeritus faculty with the Department of Mathematics, IIT Kharagpur.

Professor Gupta was awarded the Shanti Swarup Bhatnagar Prize for mathematical sciences in 1972 by the Government of India for his "significant contributions in the field of fluid dynamics and Magnetohydrodynamics, notably on-heat transfer-in-free convection flow in the presence of-magnetic field," amongst other things. He became Fellow of The National Academy of Sciences, India (1990), Fellow, Indian National Science Academy (1980), a FICCI Awardee, 1978. Professor A.S. Gupta has passed away on 14th June, 2012.

Professor Biswanath Chakraborty

Professor Biswanath Chakraborty (M.Sc in Applied Mathematics, 1955-57) started research in Plasma Physics being inspired from Professor Nikhil Ranjan Sen. He did Ph.D. from Moscow University under the father of Plasma Physics, Professor A.A. Vlasov. It needs to mention that the BBGKY hierarchy under Meyer cluster expansion and Vlasov approximation reduces to the Vlasov equation. This Vlasov equation along with four Maxwell equations describe Vlasov Plasma Theory, a very important branch of plasma physics.

Over a long duration of last three decades of the twentieth century Professor Chakraborty made significant contributions in the field of Plasma Physics . His book 'Principles of Plasma mechanics' covers the basic courses on theoretical plasma physics from an introductory level to some specialized topics. His another book 'Electrodynamics in Rotating and other Accelerated Frames was published in 1996.

He was one of the leading Plasma Physicists in the country with Russian school of training. Professor Chakraborty served the mathematics Department of Jadavpur University till his retirement where he formed a Plasma Physics Group with dream to establish a Centre for Plasma Studies there. The administration of Jadavpur University honored his academic excellence and team spirit. They approved a Centre for Plasma Studies under the Faculty of Science in 1992. Many people from plasma and allied communities are now being benefited from this Centre.

Professor Chakraborty was not only a renowned academician but also a very wide hearted person. He possessed very rare human qualities. He always extended his helping hands to all of his students but never compromised with any nonacademic activity.

Unfortunately Professor Chakraborty suffered few years from Perkinsons desease and passed away in 2005 at the age of seventy.

Professor Mithil Ranjan Gupta

Professor Mithil Ranjan Gupta (M.Sc, 1952-54) came from a distinguished family of mathematicians: His father Manoranjan Gupta was a Professor in the Department of Pure Mathematics, University of Calcutta while his maternal uncle Prof. Nikhil Ranjan Sen was the Professor and Head of the Department of Applied Mathematics, University of Calcutta.

Prof. Gupta's had a keenly analytical mind and enormous intellectual creativity. He joined the Department of Applied Mathematics, University of Calcutta in 1978. Here his teaching flourished primarily in the subjects of mathematical physics and those on the interface areas of pure mathematics. His father had a great influence on him which was reflected in his fondness for teaching pure mathematics based topics but, of course, had a commanding expertise in other areas of mathematics as well. It was at his behest that a course on Plasma dynamics was started as a special paper in Applied Mathematics. He was an inspirational teacher and universally admired. It was to him that people went for advice, guidance and clarifications whenever in difficulty. He had a great impact on students and people who came in close contact with him.

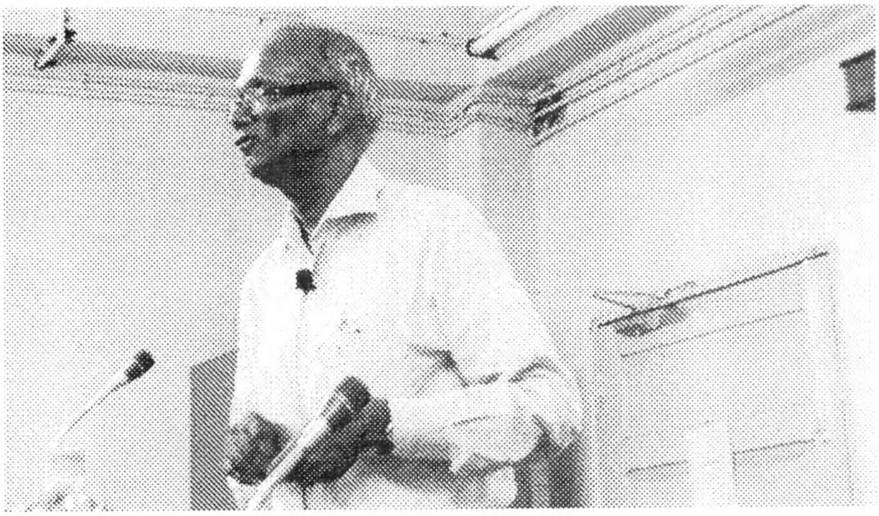
Prof. Gupta started his research career under the able guidance of Prof. Subodh K. Chakrabarti, a distinguished name in Applied Mathematics who worked with Prof. Homi J. Bhabha on the cascade theory of electron showers. In a joint paper with Chakrabarti, Prof. Gupta formulated an elegant scheme which gave the solution of the cascade equations, previously derived by Bhabha and Chakrabarty, in a form suitable for numerical computations. This work was published in Physical Review in 1956. He later switched over his research interests to problems of nonlinear dynamics and plasma physics. An important work on nonlinearity, which was written soon after he joined the Department of Applied Mathematics, was to show that the inverse scattering method can be used to obtain an exact solution of some standard nonlinear evolution equations with certain types of in homogeneities. In Plasma physics he worked in dust acoustic waves and also in a variety of other problems on dusty plasmas and their applications.

Professor Gupta passed away in July 2013 after a brief illness.

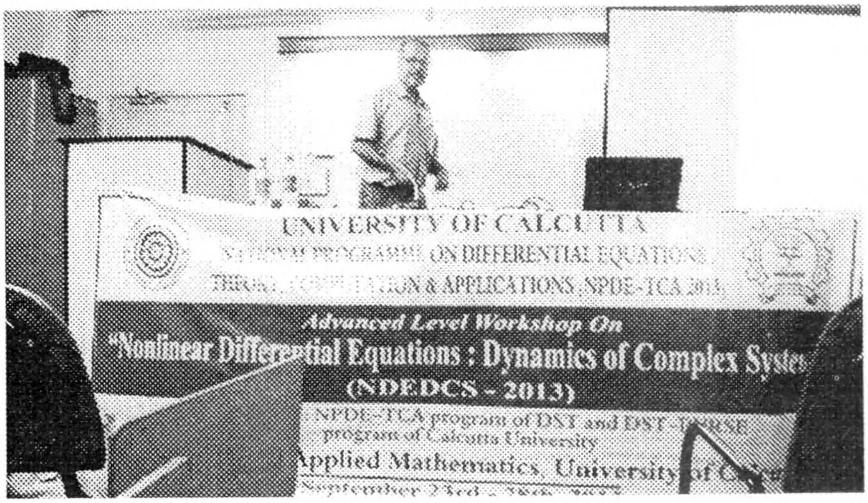
Dr. Arabinda Mukhopadhyay

Dr. Arabinda Mukhopadhyay, in 1969, a product of the Department of Applied Mathematics, joined the department as a Reader. He did Ph.D under the guidance of the legendary mathematician Prof. B. Sen. His area of research was then Elasto-dynamics. Infuenced by Prof. S.K. Chakrabarty, Dr. Mukhopadhyay started working on problems related to Mathematical Geophysics. Dr. Mukhopadhyay gradually got more involved with research on problems related to Geophysics and was acclaimed as the first scientist in India, who used mathematical modeling techniques for solving problems of Theoretical Seismology and Geophysics. In 1977, Dr. Mukhopadhyay was invited to work as a Visiting Professor in the world famous Department of Applied Mathematics and Theoretical Physics (DAMTP) of the University of Cambridge, U.K. In 1982, he became Professor at relatively young age. He was elected a Fellow of Royal Astronomical Society London, U.K., a member of the seismological cociety of America and a member of the American Geophysical Union. He was the founder member of the West Bengal

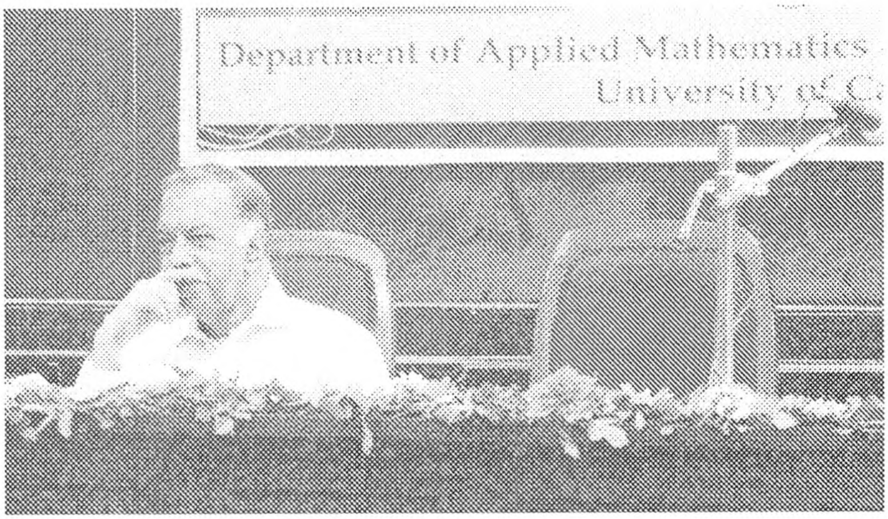
Academy of Science and Technology (WAST). He was elected a Fellow of the National Academy of Sciences in India (NASI), Allahabad. He was also a receipent of prestigious Premchand Roychand Scholarship (PRS) from Calcutta University. Professor Mukhopadhyay was twice visited by the International Centre for Theoretical Physics (ICTP), Trieste to offer specialized courses on mathematical modeling in theoretical seismology and geophysics. He was the Chairman of the two national committees formed by CSIR, India on (i) Physics of the earth (ii) Tectonophysics. He had very close academic collaboration with the stalwarts like Professor Leon Knopoff of University of California, Los Angelis, Dr. J.A. Hudson of the University of Cambridge, U.K, Prof. S.D. Nigam of IIT, Madras, Prof. V.K. Gaur, the then Secretary, Unfortunately we have lost him at a very early age.



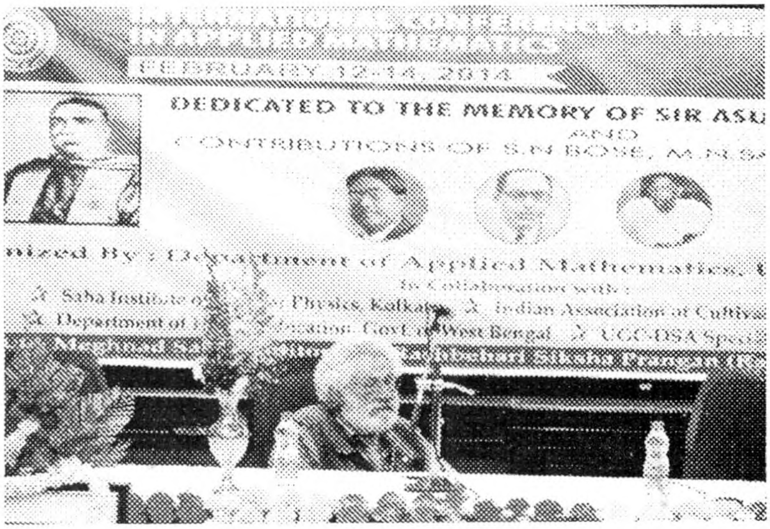
Prof. Deepak Dhar, TIFR, Mumbai is delivering lecture on "Linear and Nonlinear Diffusion Equations", September 23-28, 2013.


UNIVERSITY OF CALCUTTA
ON DIFFERENTIAL EQUATIONS
& APPLICATIONS NPDE-TCA
Advanced Level Workshop On
"Nonlinear Differential Equations : Dynamics of Complex Syste
(NDEDCS - 2013)
NPDE-TCA program of DST and DST-
program of Calcutta University
Applied Mathematics, University of C

Dr. Soumitro Banerjee, Indian Institute of Science Education and Research(IISER), Kolkata is delivering lecture on "**Hybrid Dynamical Systems and Border Collision Bifurcations**"

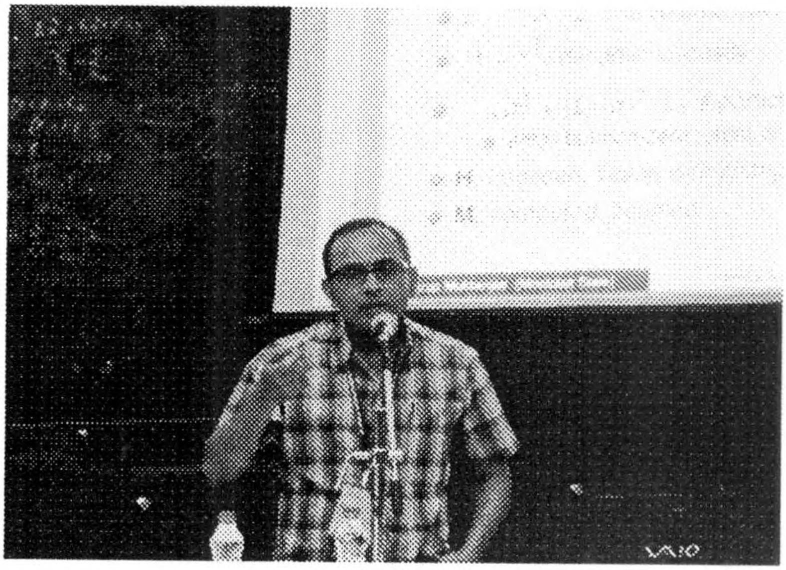


Prof. Asis Banerjee, Former Vice-Chancellor of Calcutta University is presiding over the inaugural session of the National Seminar "Nonlinearity , Complex Dynamics and Chaos in Economics and Finance", March 13-14, 2013.

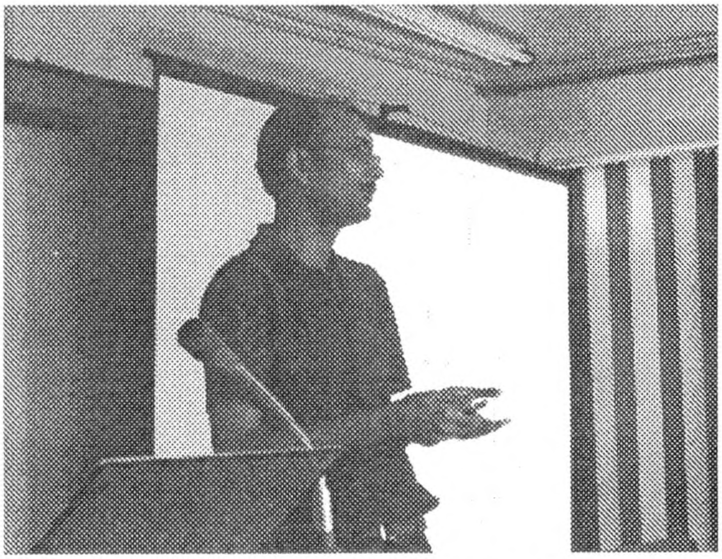

IN APPLIED MATHEMATICS
FEBRUARY 12-14, 2014
DEDICATED TO THE MEMORY OF SIR ASU
AND
CONTRIBUTIONS OF S.N BOSE, M.N.S
nized By : Department of Applied Mathematics,
In Collaboration with :
Saha Institute of Nuclear Physics, Kolkata
Indian Association for Cultiva
Department of Higher Education, Govt. of West Bengal
UGC-DSA Spe

Professor Ralph Abraham, University of California, Santa Cruz is chairing the session dedicated to Meghnad Saha.

Professor ChanchalUberoi, Former Scientist, Indian institute of Science, Bangalore is delivering lecture on "**Wave-induced Magnetic Reconnection Model in Plasmas with Application to Prediction of Space Weather" in the International Conference February 12-14, 2014**



Prof. Arup Mukherjee, Montclair State University, USA is delivering lecture on "**Laminar Ferro-Fluid:Spin, Boundary Conditions, and Stability"**



Prof. Krishnendu Sengupta, Indian Association for Cultivation of Science, Kolkata is delivering lecture on "**Strongly correlated phases and quantum phase transitions of ultracold bosons**".

Audience of the International Conference: February 12-14, 2014.